A Guide to Vegetation Control Equipment

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Information on mechanical brush control equipment can be found in FRDA Handbook 002: *A Guide to the Use of Mechanical Site Preparation Equipment in North Central British Columbia.*

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Introduction

The effectiveness of manual cutting treatments varies between species and sites and with the timing, height of cut and thoroughness of the treatment. It is recommended that experienced forest managers be consulted and the relevant literature reviewed to determine the best time to manually cut various species. For manual treatments, forest land managers may consider girdling as an option to cutting in order to achieve successful mortality with a much broader treatment time window.

Productivities reported in this review varied widely depending on contract specifications, site conditions, workers' skills and other variables. Unfortunately, there were few clear comparisons. In brushy areas with stem diameters below 7.5 cm, the clearing saw (brush-saw) out-produced the chainsaw by up to 300%. However, the production margin was greatly reduced as slopes and slash levels increased. In areas with diameters over 7.5 cm, the chainsaw was the most productive. This margin increased with rougher terrain and higher slash accumulations. Machetes, brush-hooks and Sandviks were restricted to stems below 7.5 cm and were far less productive than both types of powersaws. The least productive tool was the shears (also restricted to less than 7.5 cm) as the cutting and sweeping action could not be combined.

I. Clearing Saws (Brush Saws)

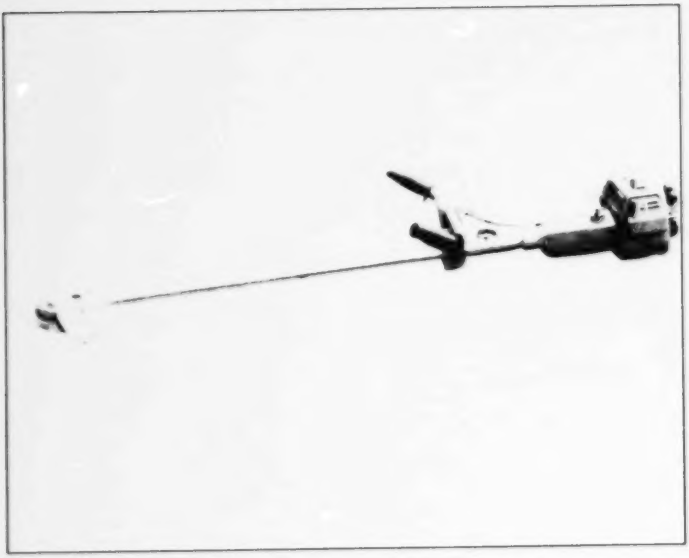

Figure 1 - Clearing Saw

1. Description

A clearing saw resembles a large weed-eater. An adjustable harness holds the unit to the workers right side at any preferred height between the waist and the knees. The engine, held behind the operator, pivots on the harness and balances against the weight of the shaft and blade. Handle bars attached to the shaft and held in front of the operator are adjustable to allow for good saw control.

2. Physical Specifications

Range of Engines	30 - 65 cc
Weight	6.4 - 10.5 kg
Engine Speeds	7500 - 9000 rpm
Fuel Capacity	0.75 - 1.2 l
Cost	$600 - $980

3. Suppliers

Consult the telephone yellow pages under "saws".

4. Availability

1. Similar to chainsaws over most of British Columbia.
2. Larger saws have fewer models and brands available.
3. For heavy duty models, users report Husqvarna has the best parts and service availability overall but local bias for the different brands and models exists.

5. Additional / Optional Equipment

(a) Blades for different applications

1. For thick brush and small trees e.g. "maxi Blade by Husqvarna - 22 teeth and 20 to 22.5 cm diameter (field sharpenable).
2. For larger brush and trees up to 20 cm e.g. Scarlett Blade - 24 teeth, 20 - 22 cm diameter (field sharpenable - round file and/or flat file).
3. For moderate brush e.g. Pointed tooth, - 30 to 80 teeth (not field sharpenable) other blades: Beaver blades - chainsaw disk (field sharpenable). Note: little forestry testing has been done on this blade.
4. For light brush (e.g. bracken fern) e.g. Multi-blades - triangular or 4 pointed blades.

Most blades are either field sharpenable (Husqvarna Maxi-blade, Sandvik safety blade and the Stihl equivalent) but some require special servicing available only through shops.

(b) Blade Guards

1. Each saw make has its own design of guard and the blade size must fit the guard.
2. Swedish saws have a small cast aluminum guard
3. Most Japanese models have a larger plastic guard.
4. A "plant protector" guard is available with two "L" shaped protrusions to protect crop trees but this hangs up in thick brush conditions.

(c) Saw Set Tools

1. Husqvarna and Sandvik sell tools for setting their saw blades.

(d) Power

1. The Swedish and Stihl brands are the most powerful; the Swedish saws are preferred by users for forestry applications requiring cutting of stems over 5 cm diameter.

(e) Harnesses

1. Different brands of brush saws have different harnesses. The expensive Husqvarna harness (currently $25 to $100) is widely preferred by users, primarily because of better padding.

6. Maintenance and Repairs

Maintenance is a critical link to good production.

The following maintenance schedule is general and the owners manual should always be consulted.

(a) Daily

1. Keep blade sharp all day.
2. Clean the air filter, replace if necessary.
3. Clean the exterior of the saw and inspect all nuts and bolts.
4. Inspect the blade and guard for cracks.

(b) Weekly

1. Ensure the angular gear is 3/4 full of gear oil.
2. Clean cooling fins, check starter cord and lubricate return spring as required.
3. Lubricate throttle linkage with thin oil.

(c) Monthly

1. Flush out fuel tank.
2. Clean fan and general area.
3. Clean around carburetor.

Caution: Proper carburetor adjustment is critical - several users report the burning out of saws not properly adjusted.

(d) Tools and Spare Parts Required in the Field

Each cutter comes complete with a tool kit with the screw drivers and wrenches required to maintain and do minor repairs such as adjusting the carburetor, changing and tightening blades and securing all nuts, bolts and screws.

In addition the following are required:

1. Gear oil.
2. Appropriate sharpening tool (round or flat file).
3. Spare spark plug.
4. Spare blades.
5. Other spare parts, e.g. extra pull cord, recoil spring, locking screws.
6. A 12 volt portable grinder and a vise can be a useful addition to a crews' tool compliment for field sharpening blades.

7. Method of Operation

1. Training is absolutely essential for safety, user acceptance and effective use of clearing saws.
2. Carry the saw by the harness (not the arms); legs apart.
3. Work with a smooth sweeping technique for top performance.
4. Keep blade speed high to ensure clean and complete cuts.

(a) For cutting stems under 7 cm diameter

1. Try to cut several stems in one sweep, pivoting with your knees (not your lower back) and following with your body.
2. Release the throttle between cutting operations but give frequent bursts to maintain blade speed.

(b) For cutting larger stems

1. The 10 - 11 o'clock part of the blade is best for good control; the 12 - o'clock could cause a wild kick back to the right.
2. The falling direction is controlled by using the saw to cut and move the stem in the opposite direction of falling.
3. The rotation of the blade (counter clockwise) is used to push forward or pull back the stem.
4. Incline the blade on side cuts to ensure the stem slides off the blade.

5. For falling trees over approximately 7 cm three cuts are required to gain directional control: face cut, undercut, and back cut.
6. Never use the saw to pry over a tree - leads to shaft or blade breakage.
7. Work in a systematic manner through the work area.

8. Safety

Clearing saws are safer than chainsaws because saw kickbacks are away from the operator and the harness system does not allow the operator's hands or feet to contact the blade.

1. Proper training is important for the safe operation of brush saws.
2. Maintain a minimum working clearance of two tree heights apart, down to a minimum of 5 metres.
3. Always approach the saw operator from the operators field of view.
4. Lock the shaft and wear gloves when sharpening the blade.
5. Check for cracks in the blade and guard before operation, both must be in good condition.
6. Ensure the blade is tight, sharp, set and jointed.
7. Keep the clutch and idling speed properly adjusted so that blade does not rotate at idle.
8. Always turn off motor when working close to the blade.
9. Protect the blade or remove it during transport.
10. Normal Workers Compensation Board requirements must be met for brush saw operations which are classified as an "A" hazard.
11. All the clearing saws have effective anti-vibration mounts to protect the operators hands from vibration.
12. After refuelling, move the saw before starting to avoid a saw fire.
13. Have belt fire extinguishers ready.

Personal Protective Equipment

1. Hearing protection.
2. Eye protection.
3. Hard hat.
4. Caulk boots.
5. Gloves.
6. Whistle.
7. Pressure dressing.

9. User Assessment

Users considering clearing saws are referred to Conway-Brown (1985)[1] which provides a thorough review of one assessment of different makes and models of clearing saws and their accessories. The critical link to user acceptance of this tool and its safe use is a good training program by a qualified, experienced trainer.

10. Advantages

- Much safer than a chainsaw.
- Easy on the back - has excellent ergonomic design.
- More efficient and productive than other tools for all brush and trees up to 7.5 cm diameter but only moderately suited for cutting low herbaceous brush and grass (plugs up).

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[1]Conway-Brown, M. "Manual Control of Red Alder with Clearing Saws, Operations Report and Equipment Assessment", Prepared under contract to Ministry of Forests and Lands, Silviculture Branch; 1985, 57 pp.

- Crews prefer them over chainsaws for most suitable clearing and weeding applications.
- Skilled operators can control the falling direction of stems up to 15 cm better than with a chainsaw.
- Can cut stems lower to the ground with less effort than other manual tools.
- The operator can use the shaft to reach into places that would be difficult to get at with other tools and avoid working in a tangled mess.

11. Limitations and Disadvantages

- Difficult to find or train good operators; this results in lower than expected production and higher saw maintenance and repair costs.
- Cannot fall large diameter trees (>16 cm) and productivity in trees over 7.5 cm is reported to fall dramatically although this may be an operator related problem.
- More restricted by terrain, slash and snow depth than chainsaws.
- Crop trees in established plantations are often damaged when they are hidden by brush as the saw sweeps back and forth.
- Air intakes tend to draw in falling snow and plug up the saw (some operators tape over part of the air intake with no reports of overheating).
- Inexperienced operators may set the carburetor too lean, resulting in engine seize-up.
- Much higher down-time than hand-powered cutting tools.
- Steep slopes limit productivity.
- Expensive.

12. Suitability

- Easily visible crop tree seedlings.
- Low slash conditions.
- Target trees smaller than 7.5 cm diameter.
- Flat to gently sloping terrain.

13. Miscellaneous Considerations

Forestry users of clearing saws in B.C. widely prefer Swedish made saws such as the Husqvarna for their superior design, ease of operation and availability of parts and service. Other makes and models are used and suitable for lighter forestry applications (light to moderate brush) but not for larger stems or clearing in heavy brush.

Due to the labour intensive nature of manual cutting, workers require quality tools to maintain good production and good job attitude. Quality tools increase worker's morale and productivity and decrease down-time.

(a) Blades

- Correct blade selection is critical.
- Field sharpenable blades are not recommended for rocky sites or for cutting near to the ground as they dull too easily.
- It is more efficient to change dull blades than to field sharpen them.
- Carbide blades are not recommended.
- A wide tooth set is preferred to reduce binding.

- Regular circular saw blades can also be used if they can be drilled to fit the clearing saw arbor.

(b) Guards

- The guards on the Swedish-built saws will not accommodate larger saw blades but are preferred because they are close-fitting and do not catch in brush as much as other larger designs.

14. Productivity

The clearing saw has a higher productivity than other manual cutting tools, including powersaws, for stands with stem diameters below 7.5 cm. Productivity reportedly varied widely with site conditions, contract specifications and worker skill and training. In ideal conditions the clearing saw can out-perform a chainsaw by almost 300%.

II. Chainsaw

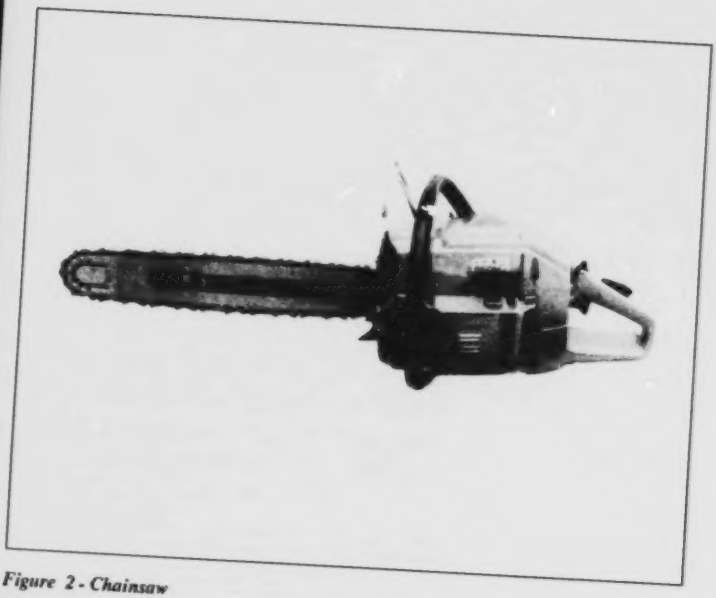

Figure 2 - Chainsaw

1. Description

Many makes and models of chainsaws are used for cutting trees and brush in British Columbia. This is due to the widespread availability of tools and skilled operators, as well as worker acceptance of the tool. Over the years the chainsaw has become lighter and more compact.

2. Suppliers

Consult the telephone yellow pages.

3. Availability

This varies from area to area and depends on local demand and dealerships.

4. Physical Specifications

Engine Sizes	40 - 68 cc
Weight	4.8 - 6.0 kg
Engine Speeds	8500 - 10000 rpm
Fuel Tank Cap.	0.5 - 0.75 L
Oil tank Cap.	0.27 - 0.45 L
Chain Pitch	0.325 - 0.375 in.
Cost Range	$480 - $670

5. Additional / Optional Equipment

1. Chain brakes and vibration reducing mounts for the motor are standard equipment for use in silviculture.
2. Heated handles for cold areas.
3. Various bar lengths.
4. Safety-chain (recommended for this application).
5. Falling dogs (not recommended for this application).
6. Various cutting tooth types for different applications (chisel, chipper and semi-chisel).
7. Chain protection sleeve.

6. Maintenance and Repairs

Proper maintenance and repair will reduce down time. Daily and weekly maintenance varies with different saw makes and models so consult your owners manual. A good maintenance schedule is as follows:

(a) Daily

1. Remove bar and chain; clean bar, chain brake and sprocket area; turn bar around (unless it has a guard tip); grease tip of bar; check chain brake for wear.
2. Clean the air filter - change if necessary.
3. Clean cylinder cooling fins, especially in hot weather.
4. Sharpen chain, check chain tension.
5. Clean air intakes and fan in starter cover as required.
6. Clean outside of saw.

(b) Weekly

1. Clean sparkplug and check the gap.
2. File burrs off sides of guide bar.
3. Check starter cord and lubricate return spring as required.

(c) Monthly

1. Flush out oil and gas tanks with unmixed gas.
2. Clean carburetor.

(d) Tools and Spare Parts Required in the Field

The most important spare parts are:

- Chain.
- Spark plug.
- Oil and gas caps.
- Bar nuts.
- Pull cord.

Others:

- Starter recoil spring.
- Clutch spring.
- Sprocket and worm gear.

The most frequently required tools are:

- Round and flat files with handles.
- Bar wrench.
- Grease gun.

Others:

- Allen keys.
- Muffler wrench.
- Carburetor screw driver.

7. Method of Operation

For much of the brushing work, the saw bar must be held in the horizontal position and used with a sweeping motion (for small diameter stems only). In this position avoid twisting the left hand by using the full curve of the handle. Hold the handle firmly. Throttle up before entering a cut and pulsate the throttle when cutting dense brush rather than holding the throttle open. Always watch what you are cutting. For stands with larger diameter stems use proper falling techniques. Do not cut so low as to dull the chain on rocks and exposed earth.

8. Safety

1. Always train inexperienced workers in proper saw use.
2. Maintain a minimum working distance of at least two tree heights from the nearest worker down to a minimum of 3 metres .
3. Do not cut with the tip of the bar as this section is prone to kickbacks.
4. Workers should be given written accident procedures and have an organized field communication system.
5. Always watch where you are cutting; move your body when completing a 180^0 cutting arc so that the bar can still be seen.

Personal Protective Equipment

1. CSA approved headgear.
2. CSA approved hearing protection.
3. CSA approved eye protection.
4. WCB approved fallers pants with suspenders - full leg pads if clearing.
5. Gloves (preferably knitted nylon).
6. Caulk boots (steel toes required if there is any hazard to the workers' feet).
7. Pressure dressing.
8. Whistle (attached to upper suspender or shirt).

9. User Assessment

Chainsaws are widely used (although not always the safest or most productive tool) because of the availability of tools and trained operators.

10. Advantages

- Widely available.
- Many skilled operators.
- Only need one tool if manual clearing is done in conjunction with another stand treatment requiring a chainsaw (e.g. juvenile spacing).
- A versatile tool that can easily cut slash of all sizes out of the way.
- Better suited than clearing saws for safe, efficient falling of larger stems.
- Better suited to deep snow and heavy slash than clearing saws.

11. Limitations and Disadvantages

- Not as safe as clearing saws, especially where contracts specify a low cutting height.
- Strenuous on the operators back when cutting low to the ground.
- More down-time for repairs and maintenance than hand-powered cutting tools.
- Requires more training than hand-powered cutting tools (but less than clearing saws).
- Noisy.
- With prolonged use vibrations can affect operators.
- Chainsaws are heavy and require gas and oil to be carried into the field.
- Dirt and rocks dulls the chain when contracts specify a low cutting height.
- Not suited for cutting low herbaceous growth or grass as saw will plug up.
- Expensive compared with hand-powered tools (usually less expensive than clearing saws).

12. Suitability

- Many large stems to be cut over 7.5 cm diameter.
- In rough terrain and heavy slash.
- Limited brush.

13. Miscellaneous Considerations

- The best design is the narrow profile saw.
- Selection of the appropriate make and model depends on many factors including availability of parts and service and matching size of saw to the brush conditions expected.
- The chipper or semi-chisel tooth chain types are recommended over the chisel tooth for conditions in which the chain will quickly dull (e.g. sand near creeks, dirt in moss or while cutting close to the ground).
- Smaller saws are sometimes preferred for lighter brush conditions.
- Damage to crop trees is more pronounced using power tools; some workers use saws in pure brush areas and finish close to crop trees with hand-powered tools.

14. Productivity

Productivities reported varied widely depending on contract specifications, site conditions, worker skill and many other variables. Manual cutting of brush using chainsaws is most productive when there are many larger diameter stems to be cut. If the treatment area consists largely of brush and small diameter tree stems (less than 7.5 cm) then the clearing saw should be considered as a safer and more productive tool.

III. Sandvik

Figure 3 - Sandvik

1. Description

Sandviks were designed as safe, efficient clearing and brushing tools. Sandviks are also known as the Swedish Brush Axe and are imported by a number of suppliers. They are made of a steel D-shaped head with a replaceable blade as part of the head that is attached to a wooden axe-type handle.

2. Suppliers

Hardware stores, forestry and agricultural suppliers.

3. Availability

Widely available throughout B.C.

4. Physical Specifications

Total length	71 cm
Weight	near 1 kg
Blade Length	18.5 cm
Price	$16 - $23

5. Additional / Optional Equipment

Spare Blades	$5 - $6
Spare Handles	$5 - $8

6. Maintenance and Repairs

1. Sharpen blade when dull, (use gloves).
2. Replace blade if broken or worn out.
3. Replace handle if cracked.
4. Sand handle smooth.

(a) Tools and Spare Parts Required in the Field

1. Flat file.
2. Spare blade.
3. Spare handle.

7. Method of Operation

When cutting whips and some brush, bend the stem over with one hand and strike with the blade at the point of maximum stress. Brush that does not whip should be chopped with a down and sideways motion. Never cut towards yourself. Do not leave any branches below the cut.

8. Safety

1. Workers should be at least two tree heights apart down to a minimum of 3 metres, extend the minimum in wet conditions.
2. Keep the tool sharp, replace blade if worn or bent.
3. Have a good footing before swinging.
4. Move the tool so that it cuts away from the worker.
5. Hold the tool firmly in a gloved hand.
6. Tool handle should be kept smooth and clean.
7. Always wear gloves when sharpening as users report this is when most accidents happen.
8. Face shields should be worn when working in brushy areas.
9. Cut all brush as close to the ground as possible; do not leave dangerous stubs.
10. Watch out for the blade glancing off.

Personal Protective Equipment

1. Good grip gloves.
2. Hard hat.
3. Caulk boots.
4. Pants with protective leg pads.

9. User Assessment

This tool is commonly used as brushing and clearing tool for manual projects.

10. Advantages

- Quite user safe as compared to machete, brush hooks, hatchets and chainsaws.
- Widely available.
- Low maintenance, easy to replace blade.
- Can be used to selectively brush out around crop trees which may be damaged or scarred by manual power cutting tools.
- Requires little training to use safely and effectively.
- Can be used in all weather and most terrain conditions where workers can get a firm footing.
- Quiet.
- Inexpensive.

11. Limitations and Disadvantages

- Low productivity compared to clearing saws or chainsaws.
- Blade sometimes comes off when blade hits an object solidly.
- Maximum stem diameters reported cut on an operational basis were 6 - 7 cm.

- In wet conditions the handle can slip out of the worker's hand.

12. Suitability

- Low and medium brush, small diameter stands where power tools are not an option due to various factors (e.g. inexperience or untrained crew or where brush growing close to crop trees).

13. Miscellaneous Considerations

In situations where herbaceous growth occurs, the length of the cutting edge of the Sandvik may limit potential production. In such instances, machetes may be more efficient although not as safe. Sandviks are best used as a backup tool for power tool cutting operations where brush near crop trees needs treatment.

14. Productivity

- Low in comparison to clearing saws and chainsaws.

IV. Machete and Brush Hook

Figure 4 - Machete

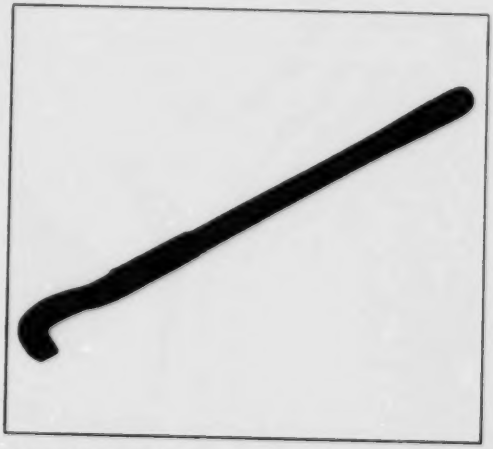

Figure 5 - Brush Hook

1. Description

Machetes used for cutting brush, whips and small saplings vary widely in design, quality and price. They usually have a 46 - 61 cm blade securely attached to a handle grip.

Brush hooks consist of a treated steel 23 to 27 cm blade attached to a wooden handle of various lengths similar to an axe handle. The nose of the brush hook blade is curved downward and sharpened on the inside.

2. Suppliers

Major forestry suppliers, many hardware and outdoor equipment stores and military equipment outlets.

3. Availability

Machetes - Widely available throughout B.C. although it is difficult to find a good quality machete with a blade strong enough not to bend.

4. Physical Specifications

Machetes:

Blade Length	46 - 61 cm average
Weight	0.75 - 1.25 kg
Price	$12 to $40, (sheaths $15 - $30)

Price is not indicative of quality

Brush-hooks:

Length	45 to 86 cm
Weight	0.75 to 1.0 kg
Blade Length	23 to 27 cm
Price	$30 to $45, (sheaths $10 - $18)

5. Additional / Optional Equipment

Machetes:

- Sheaths - usually leather.

Brush-hooks:

- Spare wooden handles.
- Sheaths.

6. Maintenance and Repairs

Machetes:

- Sharpen as required.

Brush-hooks:

- Sharpen as needed, sand handles smooth or replace if cracked.

7. Method of Operation

Used with chopping or swinging motion for brush, whips and small trees.

8. Safety

1. Keep the tool sharp, replace blade if worn or bent.
2. Have a good footing before swinging.
3. Move the tool so that it cuts away from the worker.
4. Hold the tool firmly in a gloved hand.
5. Tool handle should be kept smooth and clean.
6. Always wear gloves when sharpening.
7. Watch out for the blade glancing off.
8. Keep blade in sheath when walking.

Personal Protective Equipment

1. Gloves.
2. Hard hat.
3. Caulk boots.
4. Protective leggings.

9. User Assessment

Although there are serious safety concerns for both brush-hooks and machetes, they are still used and preferred by some workers over the Sandvik. The use of the brush hook has diminished in recent years.

10. Advantages

- Wider cutting surface than a Sandvik so more brush can be cut in one sweep.
- Quiet.
- No down-time.
- Easy to maintain and repair.
- Widely available .
- Inexpensive.
- Little training required to use efficiently.

11. Limitations and Disadvantages

- Serious safety concerns.
- Limited to a fairly small diameter of tree (max. 5-7 cm).
- Low productivity compared to the clearing saw and chainsaw.

12. Suitability

- Light to moderate brush and small diameter stems in the 0 - 5 cm range where power tools are not an option.

13. Miscellaneous Considerations

- Insist that crews use sheaths while walking even though it is inconvenient.
- Some users reported symptoms of tendonitis when using these tools.

14. Productivity

- No reports available but probably low.

V. Shears

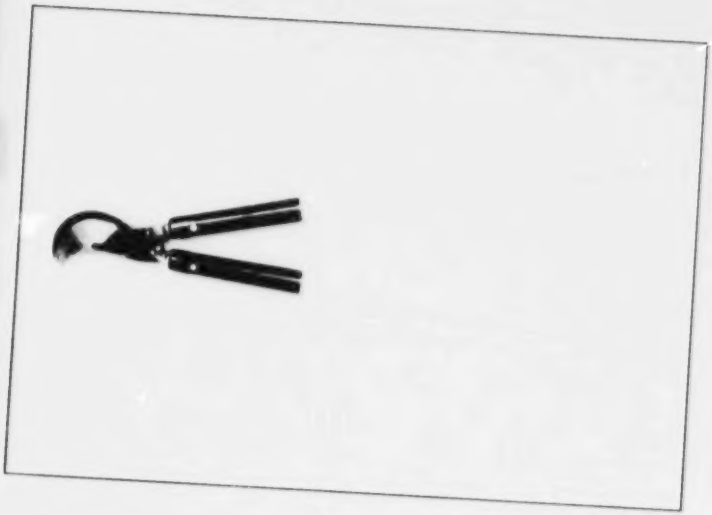

Figure 6 - Shears

1. Description

Shears come in many sizes and cutting head designs. Those used in forestry consist of high quality heat treated steel blades - one of which is curved and the other straight, or one that acts as an anvil against which the other cuts. Lightweight wooden handles of various preferred lengths are attached to each blade. The blades are joined by a bearing bolt on which the cutting blades pivot. Added cutting power is usually applied by gears, ratchet or various power enhancing devices integral to the tool.

2. Suppliers

Refer to telephone yellow pages.
One type preferred by users is the Corona Heavy Duty Lopping Shear H-29 available from:
Canadian Forestry Equipment Ltd.
17212-106 Ave.
Edmonton, Alberta
T5S 1H9
Phone: (403) 484-6687

3. Availability

Shears are widely available, however selection of good light weight shears with a 7.5 cm cutting capability is very limited.

4. Physical Specifications

1. Various handle lengths, 30 to 90 cm.
2. Wooden or metal handles (wooden preferred).
3. Various cutting capabilities; 2.5 to 7.5 cm (Corona).
4. Heat treated steel blades.
5. Both blades curved (as on the Corona) or anvil shears.
6. Anvil-type blades are replaceable.

5. Additional / Optional Equipment

A shoulder harness is available for the Corona to take the weight and reduce back strain for the operator.

6. Maintenance and Repairs

1. Less expensive models found in most hardware stores and forestry supply centres do not stand up to forestry applications and the blades usually break.
2. Good quality shears require occasional sharpening (more frequently if cutting near exposed soil and rock).
3. Lubricate bearing bolt, blade and power enhancing device as required.

(a) Tools and Spare Parts Required in the Field

1. Appropriate file (flat file for anvil action shears, half-round for curved).
2. Box-end wrench for bearing bolt.
3. Lubricant.

7. Method of Operation

Holding one handle in each hand use the shears like a pair of scissors, cutting off the stem at the desired height.

8. Safety

1. Stay two tree lengths away from nearest person when falling larger whips and saplings.
2. Use gloves when sharpening.
3. Cut all brush close to the ground to avoid dangerous stubs.

Personal Protective Equipment

1. Caulk boots.
2. Gloves with good grip.
3. Eye and face protection for brushy areas.
4. Approved headgear.

9. User Assessment

It is difficult to find shears which will stand up to forestry use. Shears are not widely used except for pruning purposes. There is occasional use of shears for manual cutting of brush or small saplings; limited to some juvenile spacing and minor brushing where user safety is a major concern.

10. Advantages

- Safe.
- Requires little training to be used effectively.
- Low maintenance (except in areas of exposed soil or rock).
- Can be used to selectively cut out brush around crop trees which may be damaged or scarred by power cutting tools.
- Can be used in all weather.
- Quiet.

11. Limitations and Disadvantages

- Low productivity; only cuts one stem at a time.
- Dulls easily when near soil or rock.

- Some of the best shears (e.g. Porter Pruners) are made with metal handles and are too heavy for forestry applications.
- Hard on the back and legs when crouching down or bending over - harness system available for the Corona relieves this problem.
- Not good for trees over 7.5 cm diameter, low herbaceous shrubs or grass.

12. Suitability

Shears are best used for manually cutting brush and whips up to 7.5 cm diameter where crew safety is a concern, power tools are not an option and maximum crop tree protection is desired. They are most advantageous in established plantations where crop trees are difficult to see and the number of stems to cut is low (e.g. for cleanup projects around crop trees).

13. Miscellaneous Considerations

- It is very important to maintain the bevel angle on the blade to make clean cuts requiring the least amount of energy.
- A harness system is recommended.
- Long handled shears (>72 cm) are preferred if a harness system is used.
- Other manual tools, particularly power tools, are much more productive but require more training to use safely and effectively.

14. Productivity

- Lowest of all the tools reported.

Appendix 1
Suitability of Manual Clearing Tools

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Introduction

A girdled tree is one in which the bark and the cambium layer (phloem) is completely severed around the full circumference of the tree stem. This has been used world wide to induce a variety of effects in various tree species.[1] In this guide the desired effect of girdling is the killing of the tree.

Girdling cuts off the downward movement of carbohydrates produced by the foliage but the upward translocation of materials from the roots continues. The desired result is a tree with dead roots and foliage.

The girdle should be wide enough to ensure that the tree will not heal the wound. For species commonly girdled in B.C., recommended girdling widths vary from 1.5 cm to 2.5 cm. Two or more cuts may be required to achieve this. It is commonly agreed that the width of a chainsaw kerf is marginally effective and there are reports of chainsaw girdles growing over, especially in red alder.

Girdling is reported to be an effective treatment for many target species, subject to certain conditions. It works well on coniferous and many deciduous stands and is much more effective than the cutting of stands.[2]

Productivity reported in the user survey varied. Productivity with girdling tools depends on many factors: stem density, average diameter, branchiness (especially close to the ground), terrain conditions, choice of tools and worker esperience.

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[1]Noel, A.R.A. "The Girdled Tree", Department of Botany, University of Natal, Pietermaritzberg, South Africa, Botanical Review; 1970, pp 162 - 199

[2]Beese, W.J. "Manual for Alder Control: A Review with Recommendations" Presentation to the 1985 MacMillan Bloedel Annual Foresters Meeting, Qualicum, B.C.; 1985, 10 pp

I. Chainsaw

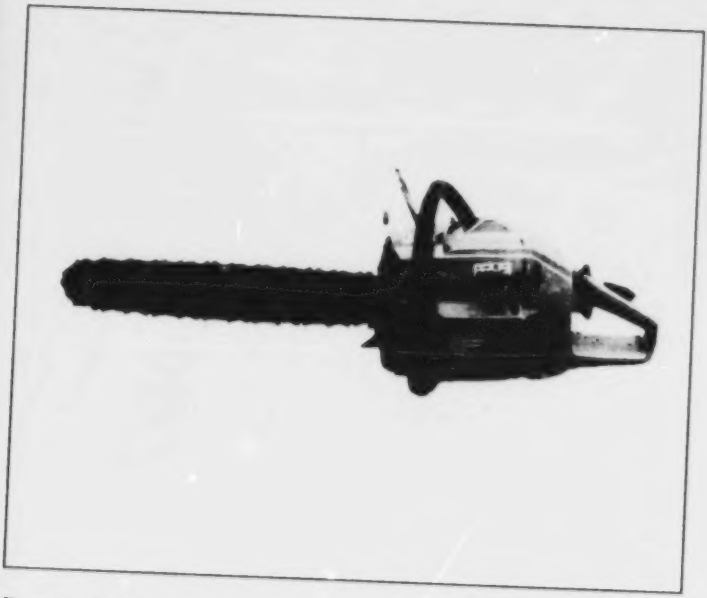

Figure 1 - Chainsaw

1. Description

Chainsaws of various makes and models are used to girdle trees during stand tending operations. The use of chainsaws requires two complete cuts through the bark and cambium layers. The use of chainsaws for girdling is not recommended due to safety and other concerns.

2. Suppliers

Consult the telephone yellow pages.

3. Availability

Varies from area to area and depends on local demand and dealerships.

4. Physical Specifications

Engine Sizes	40 - 68 cc
Weight	4.8 - 6.0 kg
Engine Speeds	8500 - 10000 rpm
Fuel Tank Capacity	0.5 - 0.75 l
Oil tank Capacity	0.27 - 0.45 l
Chain Pitch	0.325 - 0.375 in.
Cost Range	$480 - $670

5. Additional / Optional Equipment

1. Chain brakes and vibration reducing mounts for the motor are standard equipment for use in silviculture.
2. Heated handles for cold areas.
3. Various bar lengths.
4. Safety-chain (recommended for this application).
5. Falling dogs (not recommended for this application).
6. Various cutting tooth types for different applications (chisel, chipper and semi-chisel).
7. Chain protection sleeve.

6. Maintenance and Repairs

Proper maintenance and repair will reduce down time. Daily and weekly maintenance varies with different saw makes and models so consult your owners manual. Refer to Section A, page 9 for a maintenance schedule.

7. Method of Operation

Two parallel cuts are made around the stem of the tree 10 - 15 cm apart using the straight part of the bar. Some girdling has been done by throttling the saw up and then scalping a band of bark and cambium off the tree. This method is effective but slow. Some users report girdling by 'scarfing' or scraping a 5 - 7.5 cm wide ring of bark and cambium from the tree. This makes a good girdle but is slow.

8. Safety

1. Always train inexperienced workers on proper saw use.
2. Workers should be given written accident procedures and have an organized field communication system.
3. Maintain a minimum working distance of at least two tree heights apart; do not cut over 0.5 cm into the sapwood so tree stability is maintained.
4. Do not cut with the tip of the bar as this section is prone to kickbacks.
5. Always watch where you are cutting; move your body so that the bar can be seen at all times.
6. Do not girdle trees that can fall onto a travelled roadway.

Personal Protective Equipment

1. CSA approved headgear.
2. CSA approved hearing protection.
3. CSA approved eye protection.
4. WCB approved fallers pants with suspenders - full leg pads if clearing.
5. Gloves (preferably knitted nylon).
6. Caulk boots (steel toes required if there is any hazard to the workers' feet).
7. Pressure dressing.
8. Whistle (attached to upper suspender or shirt).

9. User Assessment

Chainsaws have found widespread use as girdling tools mainly because the girdling is often done in conjunction with other stand treatments requiring the use of chainsaws, (e.g. juvenile spacing) and because many users of chainsaws have been reluctant to use manual girdling tools.

10. Advantages

- When carrying out a stand treatment such as juvenile spacing the saw can be used for both spacing and for girdling of scattered deciduous or residuals.
- Can girdle thick barked species such as large cottonwoods and residual conifers which are difficult to treat with most other girdling tools.
- Can remove live limbs below girdle.
- No upper size limit of trees that can be girdled.

11. Limitations and Disadvantages

- The tip of the bar is frequently used, increasing the risk of kickbacks.
- It is recommended that chainsaws not be used to girdle trees under 25 cm diameter as it is difficult to control the depth of cut. Cuts into the sapwood will make the tree susceptible to breaking off and result in coppice growth of deciduous species. Concern for tree stability increases as tree diameter decreases.
- The width of the chainsaw kerf is not enough to ensure mortality of some tree species like red alder which may grow over in some site conditions even when properly applied.
- The saw is heavier than most other manual girdling tools used and requires that gas and oil be carried along with the worker.
- The use of chainsaws requires trained and experienced operators.
- High maintenance and repair with more down-time compared to other manual girdling tools.
- Noise and vibrations.
- Expensive relative to other girdling tools.

12. Suitability

- Stems over 25 cm diameter, various terrain conditions but with little brush.

13. Miscellaneous Considerations

- Girdling using chainsaws has serious safety concerns.
- Users report that smaller saws are preferred for girdling.
- Semi-chisel or chisel toothed are the most widely used.
- Other manual girdling tools should be considered for girdling projects in small diameter (less than 25 cm) stands especially where tree stability is a concern.
- Inexperienced workers require a significant amount of training.
- Only professional quality saws should be used to reduce downtime.
- Many users still prefer the flexibility that chainsaws provide.

14. Productivity

Productivity depends on many variables including stem diameter, stand density, terrain, brush, low live branches, experience of saw operator and saw downtime.

II. Sandvik

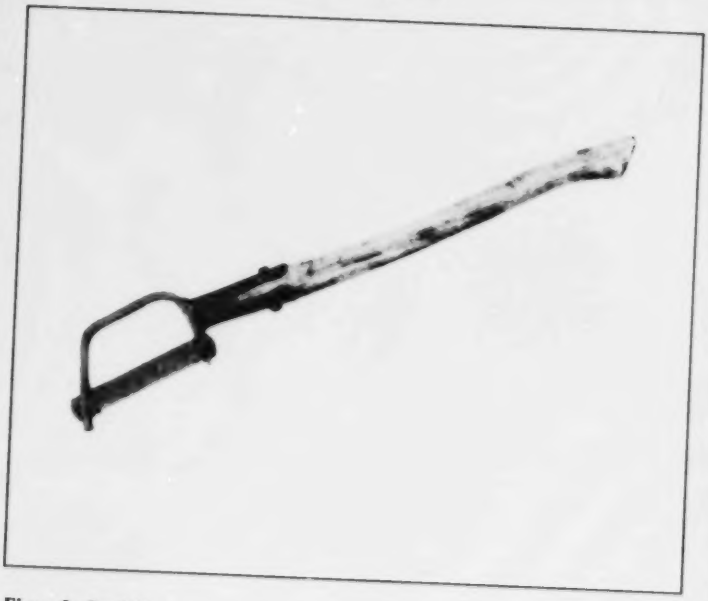

Figure 2 - Sandvik

1. Description

Sandviks were designed as clearing and brushing tools but have also been used for girdling some deciduous and coniferous species. Sandviks are also known as the Swedish Brush Axe and are imported by a number of suppliers. They are made of a steel D-shaped head with a replaceable blade which is attached to a wooden axe-type handle.

2. Suppliers

Hardware stores, forestry and agricultural suppliers as listed in the telephone yellow pages.

3. Availability

Widely available throughout B.C.

4. Physical Specifications

Total length	71 cm
Weight	near 1 kg
Blade Length	18.5 cm
Price	$16 - $23

5. Additional / Optional Equipment

Spare Blades	$5 - $6
Spare Handles	$5 - $8

6. Maintenance and Repairs

1. Sharpen blade when dull, (use gloves).
2. Replace blade if broken or worn out.
3. Replace handle if cracked.
4. Sand handle smooth.

(a) Tools and Spare Parts Required in the Field

1. Flat file.
2. Spare blade.
3. Spare handle.

7. Method of Operation

Used like an axe with a chopping motion for girdling trees. A complete ring of overlapping downward and sideways chops into the sapwood of the tree remove a notched ring of bark and cambium. The Sandvik is a safer and more efficient tool than a machete for clearing brush around trees to be girdled and for lopping off live branches below the girdle. Girdling can also be done by using a vertical slicing motion to peel a girdle around the tree. This method is slow and quality control is difficult.

8. Safety

1. Workers should be a minimum of 3 metres apart, farther in wet conditions.
2. Keep the tool sharp, replace blade if worn or bent.
3. Have a good footing before swinging.
4. Move the tool so that it cuts away from the worker.
5. Hold the tool firmly in a gloved hand.
6. Tool handle should be kept smooth and clean.
7. Always wear gloves when sharpening - users report this is when most accidents happen.
8. Face shields should be worn when working in brushy areas.
9. Watch out for the blade glancing off.

Personal Protective Equipment

1. Good grip gloves.
2. Hard hat.
3. Caulk boots.
4. Pants with protective leg pads are an asset.

9. User Assessment

This tool has been used mainly as a brushing and clearing tool. In tree girdling it has found widest use as a limbing and lopping tool to remove low live limbs. Its use as a girdling tool is not recommended in many situations because of tree stability concerns and low productivity.

10. Advantages

- Excellent for lopping low live branches.
- Widely available.
- Low maintenance, easy to replace blade.
- Quiet.

11. Limitations and Disadvantages

- Not recommended for under 25 cm as it is difficult to adequately control the depth of cut.
- Limited use on stems > 35 cm or stems with flat spots due to inset of blade.

- Tree stability concerns increase as tree diameter decreases.
- Another girdling tool is sometimes needed to girdle indentations in tree trunks.
- Low productivity as a girdling tool.
- The blade sometimes disengages from the tool head if the head strikes something solidly.

12. Suitability

- Not recommended as a primary girdling tool.
- Best used as a backup tool for limbing and lopping low live branches.
- If used for girdling it should be limited to use on large diameter (over 25 cm) stems, other girdling tools are more efficient without the tree stability concerns (e.g. Chain Girdler, Kyuquot Girdler).

13. Miscellaneous Considerations

14 Productivity

- None reported but very low.

III. Vredenburg

Figure 3 - Vredenburg Girdler

1. Description

This plier-like tool is of steel plate construction and has saw teeth and ripping teeth on the inside surface. The tool was designed to be clamped around the tree and rotated under pressure to remove a complete ring of bark and cambium down to the sapwood. Two types have been available, similar in design, with one allowing for overlap of the teeth of the tool so smaller stems may be treated. Older tools do not have the additional ripping teeth attached.

2. Suppliers

Currently patented and supplied by No-Chem-Do:

Mr. Michael Conway-Brown
No-Chem-Do Contracting and Consulting
RR #3, Upper Zilinsky Road,
Powell River, B.C. V8A 4Z2;
Tel: (604) 487-9774

3. Availability

Currently available only from the supplier and subject to production limitations. Tools may be rented from the supplier.

4. Physical Specifications

Length	39 - 42 cm
Weight	near 1 kg
Maximum opening dia.	17 - 19 cm
Cost	Yet to be determined

5. Additional / Optional Equipment

Only use the newer models with the bolt-on ripping teeth. A belt for carrying the tool, spare parts and maintenance tools should be used. None are currently available for this purpose although a carpenters apron will work adequately.

6. Maintenance and Repairs

1. Very little required.
2. Sharpening of the sawing teeth is done about once a month while in use; the ripping teeth may be carefully sharpened with a round file or emery cloth in the field. **Caution** - do not over-sharpen as the teeth will dig-in too deeply and reduce productivity

(a) Tools and Spare Parts Required in the Field

1. Round file or emery cloth for sharpening ripping teeth.
2. Small triangular file for sharpening cutting or saw teeth.
3. Appropriate box-end wrenches, spare bolts and spare ripping teeth.

7. Method of Operation

Grip the tree trunk with the tool, apply pressure and rotate the tool with a back and forth motion around the trunk. The sharp saw teeth and the chisel-like ripping teeth remove the bark and cambium down to the sapwood.

8. Safety

Personal Protective Equipment

1. Hard hat.
2. Caulk boots.
3. Gloves with a good grip.

9. User Assessment

Although several published reports of this tool have reflected favorably on its effectiveness and usefulness, it is not currently receiving much attention among potential users.[1] [2] This tool has been successfully used to girdle many thin-barked tree species in British Columbia in brushing as well as in juvenile spacing (including interior pine stands). The use of this tool is limited by the maximum diameter (16 cm) which can be girdled.

10. Advantages

- Studies show that in the 4 cm to 16 cm range, productivity is as good or better than the hack and squirt methods for some coastal red alder stands.
- Operator can control depth of cut therefore not affect tree stability.
- It is not necessary to walk completely around the tree being treated.

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[1]Weaver, D. "Vredenburg Girdling Tool Trial", The Forestry Chronicle; October 1983, pp 260 - 261

[2]Hedin, I.B. "A Comparison of Productivity of Girdling and Hack and Squirt Techniques in Conifer Release.", Forest Engineering Research Institute of Canada, Interim Report, IR-383-2; 1983, 8 pp

- Double girdling is not required.
- Little training required making use of locally available labour possible.
- Low maintenance and repair time.
- Considered user-safe.
- Quiet.

11. Limitations and Disadvantages

- Can only be used for round-stemmed trees in the 3 to 19 cm diameter range; above that the productivity is very low.
- As with other manual tools, users have been reluctant to use the tool long enough to become proficient with it and revert to the use of other tools such as chainsaws and hatchets.
- Trees must be over 0.5 metres apart to properly girdle them; other tools (e.g. the Scorp) are required where some stems are closer together.
- Another tool is required (e.g. hatchet or Sandvik) to cut off limbs below girdle and for treating indentations in the stem.
- Users report initially having sore muscles in the upper torso and hands. This is attributed to the unusual muscles used to apply pressure; not a problem after a longer period of use.
- The model with overlapping jaws tends to damage the saw teeth on contact with itself.

12. Suitability

- Best for girdling 4 to 16 cm diameter range where the stems are relatively round and there are few live limbs below girdling height.
- Potentially to be the most productive girdling tool in certain stand conditions.

13. Miscellaneous Considerations

- Do not girdle over knots if possible as this may result in the tree surviving.
- Some users have sharpened one outside edge of the handle to use as a lopping tool; this met with limited success.
- Reportedly easier to use when the sap is flowing, with the exception of early spring.
- More awkward to carry than some of the other tools and as such is not usually considered as a tool to be carried along with a chainsaw.

14. Productivity Reported

- 300 to 500 trees per hour for conifer spacing.
- As fast or faster than hack and squirt in suitable stands with a treatment range of 155 to 430 stems per hour[3].
- A Russian translation[3] reports that productivity depends on the average distance between girdling trees and the power of a workers wrist; also operational time to girdle is 1/5 of axe girdling.

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[3]Marchenko, I.S. "New Girdling Tool for Brush Management in Mixed Forests", Bryansk Technological Institute, updated copy, Translated by Benemann Translation Centre.

IV. Chain Girdler (Beaver)

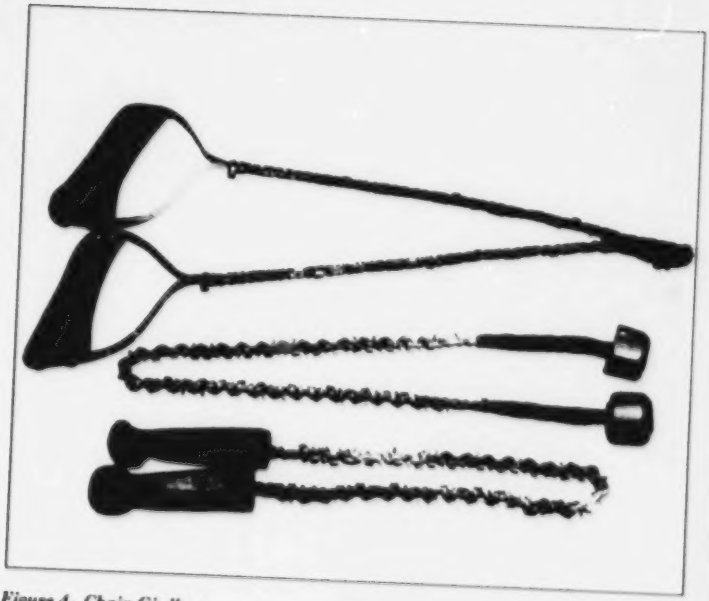


Figure 4 - Chain Girdler

1. Description

There are various chain girdlers being used. They consist of a length of single or doubled chainsaw chain with handles attached at each end. The type and length of chain used, the type of handle and the method of attaching the two-chain version together varies. This report focuses on the commercially available models.

2. Suppliers

Forestworld Supplies
304 E. 1st Ave
Vancouver B.C. V5T 1A9
Tel. (604) 875-1444
Fax (604) 875-9233

No-Chem-Do Contracting and Consulting
RR #3, Upper Zillinsky Road
Powell River, B.C. V8A 4Z2
Tel: (604) 487-9774

3. Availability

Commercial demand for this tool has been low as most contractors make their own. The model available through Forestworld and No-Chem-Do has definite design advantages. Order well in advance.

4. Physical Specifications

1. Various makes and models, handle types, chain types, lengths and handles for different tree diameters.
2. cost range - $100 - $115.

5. Additional / Optional Equipment

It is best to use the models with two chains linked together, designed to cut in both directions. For home-made models, skip-tooth chains are preferred over regular-tooth chains.

The manufacturer has made carrying pouches on a belt for carrying this tool. A carpenters apron also works well.

6. Maintenance and Repairs

1. Tend to plug up but are easily cleaned.
2. Chains that are wired together may come apart occasionally.
3. Tool should be sharpened with a round-file or with a special power driven sharpening stone developed for this purpose.
4. Some homemade models are difficult to sharpen using a round file.
5. Chain should be lubricated regularly to maintain flexibility.

(a) Tools and Spare Parts Required in the Field

1. Extra wire to bind the two chains together if they come apart.
2. Pliers to twist wire into place.
3. Extra bolts or epoxy for attaching handles to the chain depending on model.
4. Round-file.
5. Lubricant (oil).

7. Method of Operation

The tool is wrapped around the stem of the tree and pulled back and forth effecting a sawing action. By working around the tree a complete girdle is achieved.

8. Safety

Personal Protective Equipment

1. Gloves with good grip.
2. Hard hat.
3. Caulk boots.

9. User Assessment

This tool is currently receiving attention in some areas, particularly where contracts specify strictly hand-tools. It is being used to successfully girdle many tree species but has not been widely used for thick-barked species such as large cottonwood or residual conifers.

10. Advantages

- Reported to require less energy to operate than the Vredenburg Girdler but cuts more slowly.
- No upper tree size limit.
- User can treat a tree from one side so it is preferable for leaners and trees on riverbanks and cliffs - double girdling is not required using a double-kerf model.
- Little training required allowing use of local labour.
- Low maintenance.
- Relatively user safe.
- Quiet.
- Inexpensive.

11. Limitations and Disadvantages

- Slow in comparison to the Vredenburg Girdler for stems under 10 cm diameter.
- Will only girdle trees with round stems, another tool must be used for stems with indentations.
- Home-made varieties are often difficult to sharpen and tend to plug up; the manufacturer of the commercial model claims to have overcome these limitations.
- Another tool (eg Sandvik or hatchet) is required for cutting off live limbs below girdle.

12. Suitability

- For girdling of tree species with uniformly shaped stems (without indentations) over 10 cm diameter with few live limbs below girdling height.

13. Miscellaneous Considerations

- The chain girdler prototype by No-Chem-Do has the design advantage of cutting in both directions and having wider spacing between cutting teeth which allows for easier sharpening and less plugging up.
- Different types of handles are used for different applications; wood handles seem to be preferred generally, and D-handles are preferred for larger diameter trees where more pulling power is required.
- Very slow when chain is too sharp.

14. Productivity

The only reported productivity using this tool was a contractors estimate of 0.3 ha/person/day in a dense stand of 10-cm diameter red alder and 1 ha/person/day in a widely spaced stand of 25-cm diameter red alder. The chain girdler in this case was used in conjunction with the Scorp for girdling trees out of round and a Sandvik for lopping branches.

V. Kyuquot Girdler

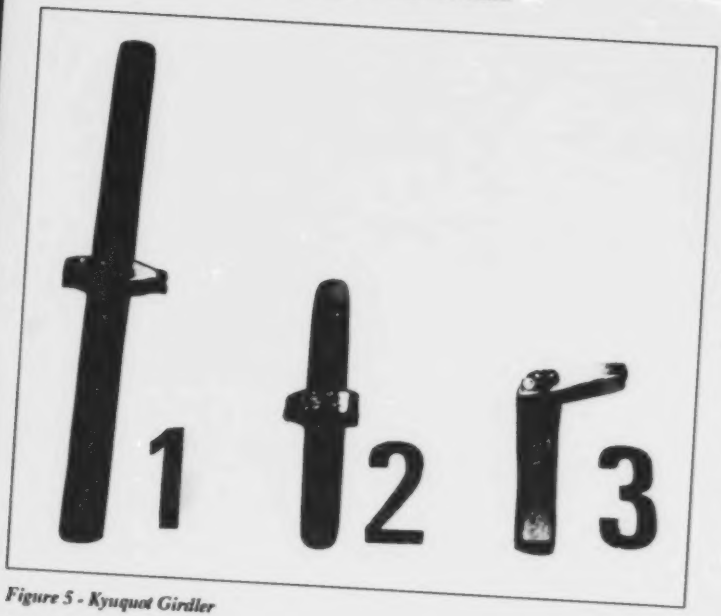


Figure 5 - Kyuquot Girdler

1. Description

These manual girdling tools were designed in 1986 for treating red alder. The horizontal cutting tools have a stainless steel cutting band centred on and around a straight piece of wood which acts both as a lever and handle. They are capable of cutting in both directions and are made in two sizes: #1 for larger stems and #2 for smaller. A vertical cutting tool, #3 is made for situations where the tree is indented and the horizontal cutting tools cannot reach.

2. Supplier/Developer

Mr. Ronald J. Frank
P.O. Box 218
Merville, B.C.
V0R 2M0
Tel. (604) 337-5183

3. Availability

Order in advance from supplier.

4. Physical Specifications

Tool #1:	
Length	41 cm
Max. width of cut	2.3 cm
Max. depth of cut	2.0 cm
Weight	280 g
Tool #2:	
Length	20 cm
Max. width of cut	2.2 cm
Max. depth of cut	1.2 cm
Weight	140 g
Tool #3:	
Length	16 cm
Max. width of cut	2.0 cm
Max. depth of cut	4.5 cm
Weight	110 g
Cost of #1, 2 or 3	$10 - $15

5. Additional / Optional Equipment

1. None available at this time.
2. Improvements or adaptations for special uses are welcomed by the developer.

(a) Carrying

Can be carried in rear pocket, in hand or in side pouch on belt. Pouch has not yet been developed for this purpose.

6. Maintenance and Repairs

1. Sharpen as required using a flat file or emery cloth.
2. Requires good sharpening technique when using a flat file to minimize wear on blade.
3. It is possible for the blade securing bolt to come loose; check and secure as necessary.

7. Method of Operation

#1 and 2 - Stand with your shoulder against the tree to develop power in drawing the tool around the trunk. One or two passes on each cut will usually give a satisfactory depth and width.

#3 - Used with a vertical chipping or scraping motion to gouge out indented areas of a tree. Very small trees may also be girdled using this tool.

8. Safety

Personal Protective Equipment

1. Gloves with good grip.
2. Hard hat.
3. Caulk boots.

9. User Assessment

These tools have been used mainly for the girdling of red alder on the coast since being developed in 1986. They have also been successfully used on various tree species throughout B.C. including birch, cottonwood, cherry, aspen and others but were not capable of girdling thick barked trees such as residual hemlock or larger cottonwood.

10. Advantages

- Provide a good cut when kept sharp.
- Light, easy to carry for occasional use along with another treatment requiring chainsaws (e.g. juvenile spacing).
- Does not affect tree stability.
- Little training required making use of local labour possible.
- Relatively user safe.
- Quiet.
- Inexpensive.

11. Limitations and Disadvantages

- Larger, thicker barked trees require several passes.
- Close inspection is required to ensure adequate depth and width of girdle.

- Requires another tool for removing live limbs below girdle.
- Not practical for thick-barked species such as large cottonwood and residual hemlock.

12. Suitability

For girdling of 4 - 25 cm thin-barked species without live limbs below girdling heigh:. For all areas, especially areas which are difficult to get other heavier tools and supplies to or where powertools or chemicals are not recommended.

13. Miscellaneous Considerations

- Production falls when trees are forked or growing close together.
- A carrying pouch should be developed and used so that tools do not get lost or get put together and dull.
- Easiest to use when the sap is flowing as the bark and cambium become soft and relatively easy to gouge out.
- Users report strain on elbow and shoulders while becoming accustomed to the tools.
- Alternative to the flat file method of sharpening should be investigated.

14. Productivity

The limited reported productivity for red alder is from 0.2 to 0.5 ha per person per day depending upon the number of stems per hectare and stem diameter.
Source: Ministry of Forests, Campbell River.

VI. Scorp

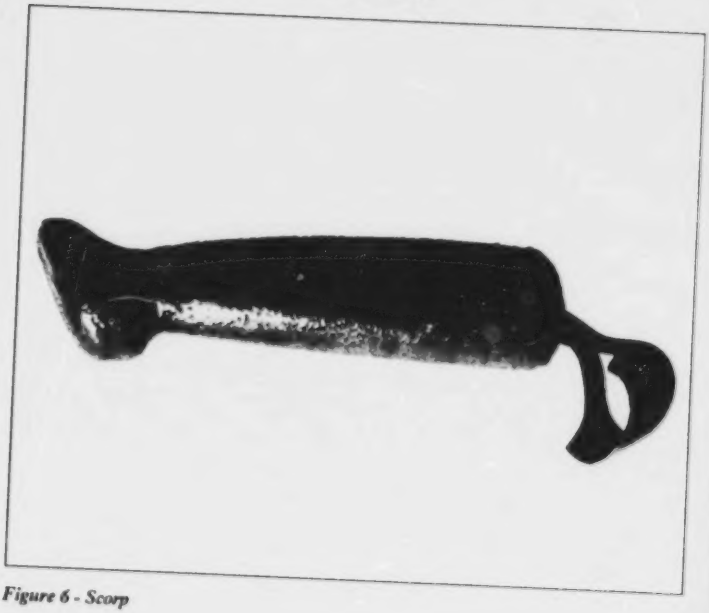


Figure 6 - Scorp

1. Description

This hand woodworking tool has a wooden handle attached to a convex, U-shaped tool-steel cutting head. It is designed for scooping out wood with a pulling motion and has been adopted as an easy to carry, inexpensive hand girdling tool.

2. Suppliers

Lee Valley Tools Ltd.
1098 S.W. Marine Drive
Vancouver, B.C. V6P 5Z3
Tel. (604) 261-2262

3. Availability

Subject to shortages. Must be imported. Order well in advance.

4. Physical Specifications

Length	18.5 cm
Weight	65 g
Width of cutting surface	3 cm
Cost	$17.50, sharpening stone - $4.40

5. Additional / Optional Equipment

1. Special sharpening stone - available from supplier.
2. Custom modifications to the handle have been made and changes to the cutting blade have been suggested to increase usefulness and productivity.
3. Can be carried easily in a pocket, tied to a belt or in a custom made belt-pouch.

6. Maintenance and Repairs

1. Handle occasionally pulls off.
2. Sharpen as required using round-file, emery paper or special sharpening stone.

7. Method of Operation

As the main girdling tool: The cutting edge of the tool is pulled through the bark of the tree creating a girdle up to 2.5 cm in width. Care must be taken to get the right amount of depth to penetrate through the bark and cambium.

As a touch-up tool: For girdling stems which are not round or where there is not much room to move around the trunk, the scorp has real utility.

For very small stems: Although slow and tedious for this purpose, it can be used in a vertical pattern so that very small stems (1.5 to 4 cm) can be effectively girdled.

8. Safety

Personal Protective Equipment

1. Use gloves when sharpening this tool.
2. Wear caulk boots.
3. Hard hat.

9. User Assessment

- No reports.

10. Advantages

- Useful for round and out-of-round stems.
- Light, easy to carry for occasional use in treatments requiring chainsaws or other tools.
- Will not affect tree stability.
- Can be used where limited space prohibits use of other tools.
- Double kerf not required.
- Relatively user safe.
- Quiet.
- Inexpensive.

11. Limitations and Disadvantages

- Requires another tool for removing low live limbs.
- Close inspection required to ensure sufficient depth and width.
- Some users report sore joints and muscles when first using this tool.
- Difficult to girdle thick-barked species.

12. Suitability

- Best used in conjunction with other tools as a touch up for trees out of round or for other stand treatments where an easily carried tool is required for occasional thin-barked trees.

13. Miscellaneous Considerations

- Reported to be particularly productive when the sap is flowing.
- May require a hatchet or other tool for a particularly deep bark indentation.

- In each new working situation ensure that the width of the girdle through the cambium is adequate (1.5 - 2.5 cm has been recommended) as the leading edge of the cutting head tends to scrape along the sapwood.
- Sharpening is critical; too sharp and it digs too deeply, slowing production; too dull and it does not cut deeply enough.
- Emery paper has been suggested as the best for touching up.
- Sharpen the inside cutting edge with a round file.
- Some users recommend sharpening the side of the tool more than the centre so it draws into the bark better.
- An adequate supply has not always been available.

VII. Machete

Figure 7 - Machete

1. Description

A machete is a short, broad, curved sword with a single cutting edge. Machetes have been used for girdling but are best for limbing and lopping in conjunction with safer and more efficient tools.

2. Suppliers

Forestry suppliers, hardware, outdoor and military equipment outlets as listed in the telephone yellow pages.

3. Availability

1. Widely available throughout B.C. although it is difficult to find a good quality machete with a blade strong enough not to bend

4. Physical Specifications

Length	46 - 61 cm average
Weight	0.75 - 1.25 kg
Price	$12 to $40, (sheaths $15 - $30)

Price is not indicative of quality.

5. Additional / Optional Equipment

1. Sheaths - usually leather.

6. Maintenance and Repairs

1. Sharpen as required.

7. Method of Operation

Used with a downward and sideways chopping motion for girdling to end up with a series of overlapping notches which result in a complete girdle.

8. Safety

1. Keep the tool sharp, replace blade if worn or bent.
2. Have a good footing before swinging.
3. Move the tool so that it cuts away from the worker.
4. Hold the tool firmly in a gloved hand.
5. Tool handle should be kept smooth and clean.
6. Always wear gloves when sharpening.
7. Watch out for the blade glancing off.
8. Keep blade in sheath when walking.

Personal Protective Equipment

1. Gloves.
2. Hard hat.
3. Caulk boots.
4. Protective leggings.

9. User Assessment

None available for machetes used as girdling tools.

10. Advantages

- Can be used for indentations.

11. Limitations and Disadvantages

- Safety concerns, especially cuts to the lower legs and other workers due to glancing off.
- Tree stability concerns.
- Quality control concerns due to control of the depth of cut being difficult.

12. Suitability

- Not recommended for girdling.

13. Miscellaneous Considerations

- Used as a back-up tool in conjunction with more efficient girdling tools.

14. Productivity

- No reports available but probably very low.

VIII. Hatchet or Axe

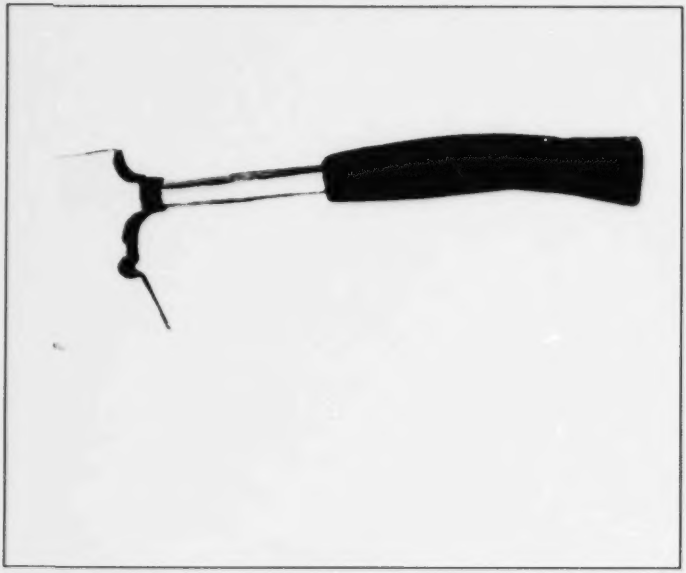


Figure 8 - Steel Handled Hatchet

1. Description

Although not specifically designed as girdling tools, hatchets and axes are widely used, mainly in pesticide-free and buffer strips in conjunction with hack and squirt applications. The tools vary widely from lightweight wooden handled hatchets to heavier double bitted axes depending on user preference. All metal hatchets used in hack and squirt operations are the most common.

2. Suppliers

See the telephone yellow pages. Most forestry suppliers and hardware stores carry a range of axes and hatchets.

3. Availability

A wide variety are available throughout the province.

4. Physical Specifications

Cost	various $10 - $60
All metal hatchet	approx. 1 kg

5. Additional / Optional Equipment

1. Blade guards.
2. Sheaths with belt loops.

6. Maintenance and Repairs

1. Ensure the head is mounted tightly.
2. Sharpen with a flat-file, whetstone or light disc grinder -if sharpening with a bench grinder keep the speed below 3000 rpm to avoid overheating the blade and losing its temper.
3. File so that cutting edge stays thin.
4. File burrs off back of head.
5. Sand wooden handles smooth - replace if cracked.

(a) Tools and Spare Parts Required in the Field

1. Flat file, whetstone or grinder.
2. Extra wooden handles and wedges.

7. Method of Operation

Use a combination of down and under-hand overlapping chops to remove a notched ring of bark and cambium.

8. Safety

1. Do not girdle trees that could fall onto a road.
2. Have firm grip before swinging.
3. Head of tool must be kept burr-free and sharp - dull tool will glance off and can injure worker. Use a good quality tool.
4. Choose a tool that weighs enough to be effective and controllable.
5. Replace cracked or dry-rotted wooden handles.
6. Carry tool in sheath or with head facing down and handle parallel to the ground.
7. Wear gloves when sharpening and using.

Personal Protective Equipment

1. Gloves.
2. Hard hat.
3. Caulk boots.
4. Protective leggings.

9. User Assessment

Compared to other girdling tools many users prefer hatchets in conjunction with hack and squirt operations. Those who use other manual tools often use hatchets for girdling indentations in irregularly shaped stems.

10. Advantages

- The hatchet is often used in hack and squirt operations and is available to use in buffer and pesticide free zones.
- Can be used for out-of-round stems and to cut off live limbs below the girdle.
- Requires little training.
- Low maintenance and little or no down-time.
- Quiet.
- Inexpensive.

11. Limitations and Disadvantages

- Worker must move completely around the tree to effectively and safely girdle it.
- Tree stability is easily disturbed; not recommended for stem diameters under 25 cm for this reason.

- Safety hazards due to glancing off.
- Some workers report tendonitis when consistently using hatchets.
- Production is slow and especially difficult with thick barked species.

12. Suitability

- Small areas of large stems (over 25 cm) but not recommended.

13. Miscellaneous Considerations

- All metal hatchets are preferred as they are not subject to breakage.
- Hatchets are best used along with another girdling tool for cutting of live limbs below girdle and indentations in the trunk.

14. Productivity

- None reported.
- Productivity is low using hatchets and axes.
- Girdling should be confined to limited areas.

Appendix One
Advantages, Limitations and Recommendations

Advantages of Girdling

1. When done properly girdling is more effective overall for killing trees than cutting, especially deciduous species.
2. Girdling can be done at any time of the year but may be more effective during certain seasons. The treatment can be carried out when ground conditions are the most appropriate; when brush species are not leafed out, wet areas are dry, fire hazard is low or when insects or heat are not a problem. Projects can be timed to take advantage of seasonally available labour.
3. Apart from the chainsaw, the girdling tools reviewed here are relatively inexpensive to purchase, use and maintain. There is no time loss or expense due to refueling.
4. A girdled tree (e.g. red alder) will take 1 to 3 growing seasons to die. This results in a gradual increase in light to the understory trees which has important implications in conifer-release applications.
5. For many species, basal sprouting is negligible after girdling but is often a problem after cutting.
6. There is much less fire hazard than with cutting as there is only a gradual build up of slash as the trees disintegrate over several years.
7. Most manual girdling tools (excepting the chainsaw) are quiet, require little user-training and are relatively user-safe. Local labour can be readily used.
8. In areas of poor access and rough terrain, lightweight manual girdling tools are more practical than powertools.

Limitations of Girdling

1. Not suited for stands with:
   a) small stem diameters (under 3 cm),
   b) excessive branches below girdling height,
   c) stems close together,
   d) some species like big leaf maple reportedly coppice when girdled,
   e) frozen stems are more difficult and slower to girdle.
2. No single girdling tool is suited to all stand types or even all trees in one stand type.
3. Worker acceptance of manual girdling tools is varied. Efficient use of girdling tools requires the operator to learn new techniques and be in good physical condition.

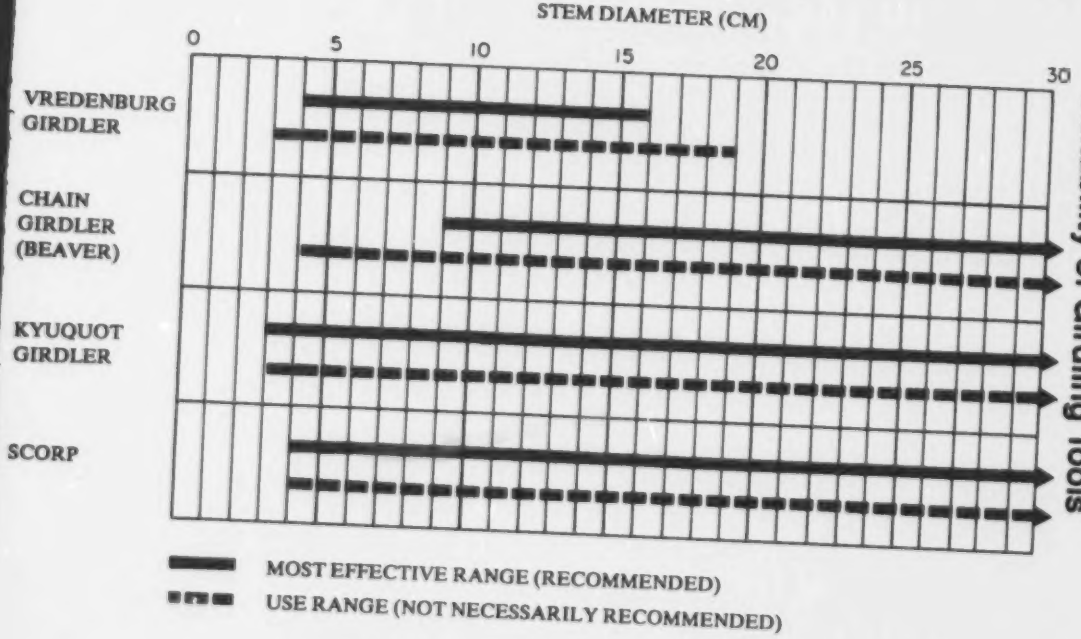
4. Girdling of trees for seed tree control may result in a 'distress crop' of cones or seeds.
5. Since a girdled tree takes up to 3 seasons to die, the technique may not be suitable for releasing crop trees under severe competition.

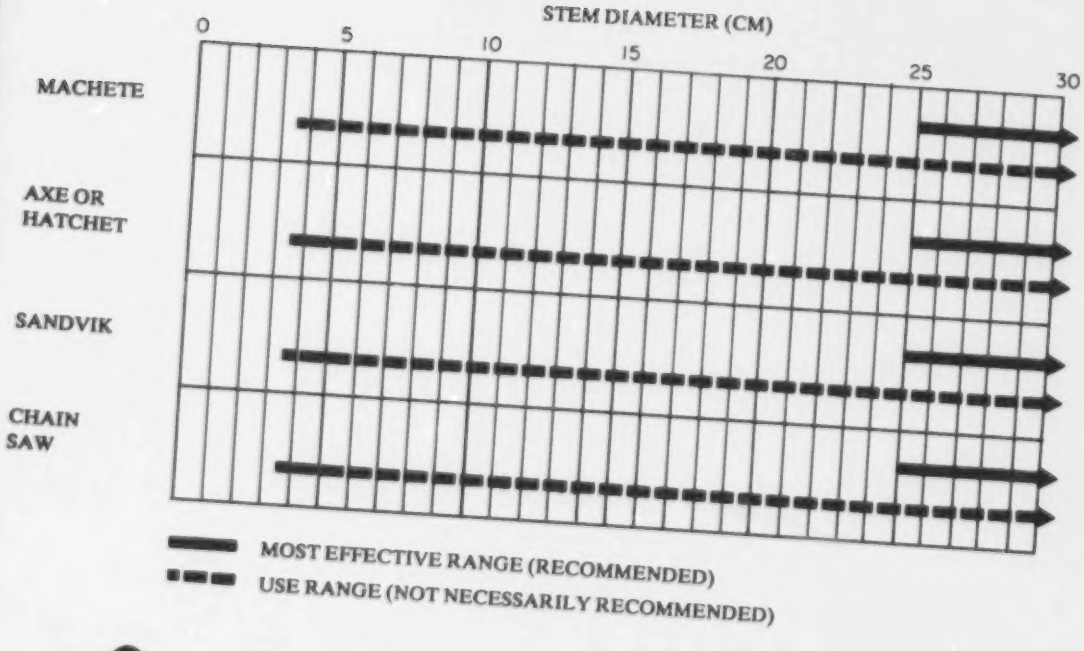
General Recommendations

Given the selection of manual girdling tools available and the efficacy of the treatment when trees are properly girdled, manual girdling is an important vegetation management treatment option. In most stands to be girdled no one tool is adequate. Usually a system or set of tools is required:

1. Where there are low live limbs;
   a) Carry another girdling tool to do most of the girdling work and use a hatchet or Sandvik to girdle indentations and cut off the low live limbs.
2. When stems are round or uniformly shaped;
   a) 4-10 cm diameter
      -use Vredenburg Girdler or Kyuquot Girdler #1 or 2,
   b) >10 cm diameter
      -use Chain Girdler or Kyuquot Girdler #2.
3. When stems are not uniformly shaped;
   a) use Kyuquot Girdler #1,2 or 3 or scorp in combination with a hatchet for excessively deep indentations in the tree.
4. When stems are close together;
   a) use the scorp or Kyuquot Girdler #3,
   b) where stems are butted up against each other use hatchet or Sandvik.
5. For large diameter stems (over 25 cm diameter breast height);
   a) use Chain Girdler, Kyuquot Girdler #1 and scorp,
   b) chainsaws,hatchets, Sandviks and machetes may be used if depth of cut is limited but they are not recommended.
6. For girdling along with another stand treatment requiring chainsaws or brushsaws;
   a) use the light, easy to carry manual girdling tools - Kyuquot Girdler, Scorp or Chain Girdler.
7. For stand diameters under 3 cm breast height;
   a) No suitable girdling tool exists.
8. For thick barked trees such as large older cottonwood;
   a) chainsaws may be the only tool capable of girdling.

Appendix Two
Suitability of Girdling Tools




STEM DIAMETER (CM)
0
5
10
15
20
25
30
MACHETE
AXE OR HATCHET
SANDVIK
CHAIN SAW
MOST EFFECTIVE RANGE (RECOMMENDED)
USE RANGE (NOT NECESSARILY RECOMMENDED)

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Introduction

Ground spraying equipment is ideal for treating low vegetation. It is very difficult to get good coverage of vegetation over 2 m. Tall brush also slows productivity and greatly increases costs.

The hand operated pumps are best suited for low volume applications (less than 200 L/ha). With power nozzles much higher application volumes can be obtained (over 300 L/ha).

Ground spraying is much more expensive than aerial but aerial applications are often impractical in small areas or sensitive watersheds. Some of the ground spraying operations are used in conjunction with aerial applications, for buffer zones and environmentally sensitive areas.

Ground Spraying Safety Considerations

Hand Carried Equipment

1. Do not spray with wind velocities greater than 8 km/hour.
2. Avoid spraying into the wind, especially while spraying taller brush.
3. Avoid walking through treated areas.
4. Always have a partner.
5. Work a minimum of 10m apart for hand pumped equipment and 20m apart for motorized equipment.
6. Never fill pack tanks more than 90% full as overflow out the vent hole in the fill cap may occur when the pack is tilted when maneuvering over rough terrain

Vehicle Mounted Equipment

1. Do not spray with wind velocities greater than 8 km/hour.
2. Avoid walking through treated areas.
3. Adjust nozzles to minimize spray drift.
4. Do not spray into the wind.
5. One person should be near the pump to shut it off in an emergency.

I. Backpack Sprayer

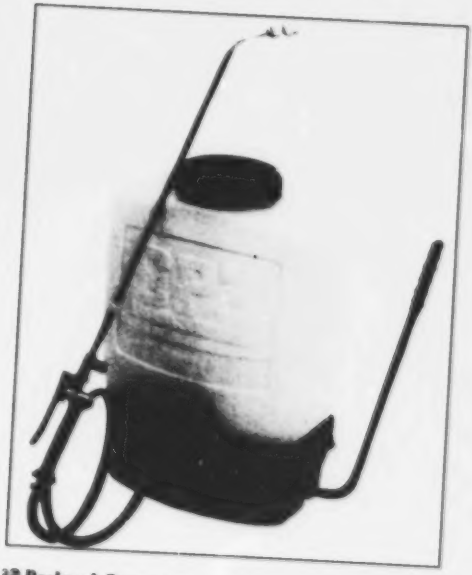

Figure 1 - CP 3® Backpack Sprayer

1. Description

Most of the backpack sprayers are similar in design. The fill hole is always at the top and quite large (10cm) to allow for easy filling. On some models the hand pump can be mounted on either the left or right side depending on the user's preference. The hose line is about 1 m long and attached to a 60 cm wand.

2. Physical Specifications

Tank capacity	15-20 L
Operating pressure	0-600 kpa
Empty Weight	4.0-5.0 Kg.

Cost:

15L	$129 - $149
20L	$98 - $249
Special forestry nozzle (for Spray Mate®)	$18

3. Suppliers

Bear Thoud®
Harry Sharp & Son
Canadian Forestry Equipment

CP3®, CP15®
Agripharm Suppliers
Forestworld

Spray Mate® (made by Solo®)
Canadian Forestry Equipment
Hardi®
Sheppard Bros.
Roland Machinery
Solo 425®
Neville Crosby

4. Availability

There is a relatively low volume of sales for backpack sprayers. This affects availability. Check with suppliers.

5. Additional / Optional Equipment

For special applications many extra parts are available:

1. Extension tube for nozzle.
2. Pressure limiting valve (built-in on some models).
3. Spray screen.
4. Pressure gauge.
5. Twin nozzle.
6. Special nozzle for forestry; brass and adjustable.
7. Spray booms

6. Maintenance and Repairs

(a) Daily

1. Clean out tank.
2. Check for leaks on the tank, hose or nozzle.

(b) Weekly

1. Clean or replace nozzle.
2. Check and replace washers as required.

(c) Tools and Spare Parts

1. Hoses.
2. Nozzles.
3. Washers.
4. Clamps.
5. Teflon tape.
6. Plastic electricians tape and padding for the straps.

7. Method of Operation

To maintain a proper operating pressure an average of 30 strokes/minute on the pump are required. The operator must work in a systematic pattern and avoid walking through treated areas. Under most conditions one sprayer will cover a 10 m swath (5 m on either side of the operator) using an adjustable nozzle. A dye can also assist in identification of treated areas.

8. Safety

1. See appendices for safety requirements while mixing or page C1 while spraying.
2. Never fill tank completely. Overflow out of the vent hole in the fill cap may occur when full tanks are tilted. To avoid this a 20 L tank should be filled to a maximum of 18 L, and a 15 L tank to 13-14 L.

Personal Protective Equipment

Essential:

1. Water resistant boots.
2. Long pants (preferably water resistant).
3. Jacket (preferably water resistant). Coveralls may substitute for pants and jacket.
4. Unlined plastic (neoprene) gloves.

User's Discretion:

1. Water resistant hood or full wide brim hard hat.
2. Face shield or goggles.
3. Respirators to be used when spraying in tall dense vegetation. Respirators may also be required under certain circumstances or as directed by the operator's supervisor.

9. User Assessment

The majority of backpack sprayers are designed for agricultural use. The Cooper Pegler (CP3 and CP15) sprayers were the most suitable for forestry use. The CP3 and Hardi RY2 20L backpack sprayers were the most popular. The major difference is the CP3 has a built in adjustable pressure regulator. Most of the wand on the CP3 is brass while the Hardi is mostly plastic. Both are reliable but must be continually checked for leaks. Teflon tape has been the best solution for leaking joints.

Users preferred the larger 20 litre tank. Most users reported discomfort with backpacks. The CP3 has padded shoulder straps and a padded hip belt which improves comfort. Many users tape padding to the shoulder straps of other backpacks. Any padding that can absorb pesticide must be removed if it becomes contaminated.

10. Advantages

- Can be very target specific. Little damage to crop trees.
- Relatively low capital cost.
- Little spray drift problems.

11. Limitations and Disadvantages

- Low productivity and labour intensive.
- Solution applications of greater than 150 - 200 L/ha are impractical over extended areas.
- For most treatment blocks fill up of backpacks may be assisted by power units (pick-up or trailer mounted tanks). This reduces walking and mixing time.
- The filled backpacks weigh over 22 kg and are uncomfortable.
- Users reported spillage from the vent hole in the tank top.
- User reported the brass wand was susceptible to leakage.

12. Suitability

- Reported least effective when stem heights were greater than 3 m.
- The backpacks should be used on brush under 2 m. Heavy slash and steep slopes will greatly decrease productivity.
- Backpacks can be effectively used in conjunction with aerial or power nozzle applications. Broadcast treatments become prohibitively expensive with delivery rates of over 150-200 L/ha.

13. Productivity

- The productivity on the coast was 50% lower than the interior due to terrain and heavy slash and brush.
- Interior; average 6 man hrs/ha with a range of 1.6 to 21.6.
- Coast; average 10 man hrs/ha with a range of 1.6 to 40.
- Productivity varies due to different delivery rates and site conditions.

II. Motorized Backpack Sprayers

Figure 2 - Motorized Backpack Sprayer

1. Description

Motorized backpack sprayers are not recommended for herbicide spraying but are used for insecticides.

The solution reservoir and gas tank are positioned above the motor. The sprayer hose is on the right hand side of the backpack. The herbicide solution is fed by gravity through a small hose opening into the main sprayer hose. The pump forces air through the sprayer hose which is mixed with the contents of the tank at the nozzle.

2. Physical Specifications

Spray tank:	11 - 12.5 L
Fuel tank:	1.25 L
Dry weight:	8 - 10 Kg
Engine:	3 to 5 hp
Cost:	$475 to $700

3. Suppliers

Model	Supplier
Wambo Allspray	Deppe Ag•Tec
Solo Mist Blower	Canadian Forestry Equipment

Most agricultural equipment outlets.

4. Availability

Low, usually not in stock.

5. Additional / Optional Equipment

1. Many different types of nozzles
2. Liquid booster pump which also stirs tank.
3. Dust and granular formulation equipment.
4. Flame throwing equipment.

6. Maintenance and Repairs

(a) Daily

1. Check for leaks
2. Tighten clamps
3. Clean sprayer tank

(b) Weekly

1. Clean spark plug
2. Clean cooling fins
3. Clean out gas tank
4. Clean muffler unit
4. Check oil level

(c) Tools and Spare Parts

1. Pull cord
2. Spark plug
3. Clamps
4. Screw driver and spark plug wrench

7. Method of Operation

The method of operation is almost identical to that of non-motorized backpack sprayers. However even more consideration to wind conditions must be given.

8. Safety

1. Never fill tank completely. Spilling out of the vent hole will occur if they are tilted when full.
2. See appendices for safety requirements while mixing or page C1 while spraying.

Personal Protective Equipment Essential

1. Water resistant boots.
2. Water resistant pants.
3. Water resistant jacket.
4. Water resistant hood or full wide brim hard hat.
5. Unlined plastic (neoprene) gloves
6. Face shield or goggles.
7. Ear protection.
8. Whistle (for emergency use)
9. Respirators to be used when spraying in enclosed spaces. Respirators may also be required under certain circumstances or as directed by the operator's supervisor.

9. User Assessment

Very limited information. The motorized backpack sprayers are not recommended for herbicide application. They are much more expensive than other sprayers and seem to be less productive. Their small 12.5 L capacity requires more frequent fill ups. Although a wide spectrum of droplet sizes is created by these sprayers, the majority are rather large resulting in run-off.

10. Advantages

Can be used to spray insecticides.

11. Limitations and Disadvantages

- Low tank capacity and frequent fill ups
- Heavy even with low tank volumes.
- More safety equipment required.
- Expensive.
- Low productivity.

- Mist produced is not suitable for herbicide application.
- Noisy.

12. Suitability

- Brush or trees under 3 m.
- Best suited for easy terrain, little slash, and low brush/trees.
- Best suited for application of insecticides.
- In dense brush will not penetrate more than 1 m to 2 m.

13. Productivity

The motorized backpack sprayers are generally less productive than other backpack sprayers because too much time is spent on walking to fill up areas. Productivity will drop dramatically unless there is a system of fill up stations located withing the treatment blocks that are fed by hoses from the main roads.

III. Spot Gun

Figure 3 - Spot Gun

1. Description

Tank capacities vary greatly in size and shape. Unlike backpack sprayers, the trigger provides the pumping action. The length of the stroke of the trigger controls the delivery rate.

2. Physical Specifications

Tank capacity:	1 - 5 L
Dosage: (adjustable)	1-20 mL
Weight:	1 Kg
Cost:	
Phillips Spot Gun	$162
Velpar Spot Gun	$35

3. Suppliers

Most large forestry equipment suppliers.

4. Availability

Availability is fair in B.C. for the Phillips and good for the Velpar.

5. Additional / Optional Equipment

1. Spear for Phillips Spot Gun for ground injection.
2. Spare parts kit for Phillips Spot Gun.

6. Maintenance and Repairs

(a) Daily

1. clean nozzle
2. clean tank

(b) As Necessary

1. replace seals

(c) Tools and Spare Parts

1. extra nozzle
2. extra seals

7. Method of Operation

Spotguns can be calibrated to deliver a thin stream of a predetermined volume. Spray directly onto the ground or adjacent to the base of the tree or brush. When treating large stems that require more than one spot application, apply the chemical to opposite sides of the stem.

8. Safety

1. See appendices for safety requirements while mixing or page C1 while spraying.

Personal Protective Equipment

Essential:

1. Water resistant boots.
2. Long pants (preferably water resistant).
3. Jacket (preferably water resistant). Coveralls may substitute for pants and jacket.
4. Unlined plastic (neoprene) gloves

User's Discretion:

1. Water resistant hood or full wide brim hard hat.
2. Face shield or goggles.

9. User Assessment

This tool was not well liked by the users surveyed.
Reported: poorly made, poor ergonomics and not consistently effective.

10. Advantages

- Target specific.
- Few fill ups required.
- Usually straight product is used, no mixing required.
- Dosage is adjustable.

11. Limitations and Disadvantages

- Leakage.
- Trigger sticks.
- Comes apart.
- Hard on the tendons of the arm.

12. Suitability

- For systemic pesticides application.
- Small treatment areas and low volume applications.
- Easy ground with little duff and few stems per hectare.
- Best results are usually obtained in the early spring and summer, but in some areas applications can be made any time the soil is not frozen.

13. Productivity

Eight man hrs/ha reported in the interior.

IV. Vehicle or Trailer Mounted Sprayer

Figure 4 - Trailer Mounted Sprayer

1. Description

The pick-up mounted and trailer mounted sprayers are similar in design. A small engine drives a pumping system. The vehicle mounted systems are on metal skids for easy loading. Trailer mounted systems are permanently fixed to the trailer. The pumping system is connected to a boom for field or roadside use or a hose and nozzle for broadcast applications.

There are many configurations possible and buyers should consult with a supplier about the best configuration for their application.

2. Physical Specifications

Tank - Vehicle mounted:
200 - 600 L
Plastic or fibreglas construction

Tank - Trailer mounted:
450 - 2000 L
Plastic, fibreglas or stainless steel

Pumps:
Diaphragm or piston type

Engine:
5 - 10 hp Briggs and Stratton or similar

3. Suppliers

Most large agricultural equipment suppliers.

4. Availability

Usually readily available.

5. Additional / Optional Equipment

1. Different types of nozzles.
2. Extra lengths of hose.
3. Hose reels.
4. Booms for field spraying, 6m to 20m wide.

6. Maintenance and Repairs

(a) As Necessary

1. Maintain pump engine.
2. Clean nozzles.

(b) Weekly

1. Check delivery system for leaks.
2. Check drive belts.

(c) Tools and Spare Parts

1. As necessary for pump engine.

7. Method of Operation

Check and calibrate spray and application rate. Most pumps have a number of pressure settings which can be set to the most suitable. Some experimentation is usually required. Pump speed must remain constant to maintain calibration and ensure even coverage.
It is often possible to use two hoses per tank if the manpower is available.

8. Safety

1. See appendices for safety requirements while mixing or page C1 while spraying.
2. A separate pick-up unit for water only is recommended.
3. Avoid pumping directly from outdoor sources of water into the pesticide tank.
4. Backflow valves on the fill hose should always be used.

Personal Protective Equipment

Essential:

1. Water resistant boots.
2. Water resistant pants.
3. Water resistant jacket.
4. Water resistant hood or full wide brim hard hat.
5. Unlined plastic (neoprene) gloves
6. Face shield or goggles.
7. Hearing protectors while near pump.

User's Discretion:

1. Respirators.

9. User Assessment

- Most users preferred using an extra-long hose and carrying the hose over slash to using a backpack.

Vehicle Mounted

- Users reported the Braber Equipment and Mitchell units to be very reliable, with no problems and very little maintenance.
- Most users prefer the Vehicle mounted systems as the trailer is harder to manoeuvre on logging roads.

Trailer Mounted

- Most popular was the Hardi system. These machines are reported to be very reliable.

10. Advantages

- Good for broadcast applications - they can cover a larger area in a relatively short period of time.
- Large capacity tank: ideal for use in conjunction with back pack units to use as a filler within the treatment block.
- Additional lengths of hose can be added.

Vehicle Mounted

- More convenient than trailer mounted.

11. Limitations and Disadvantages

- Requires 4-5 man crew.
- Not target specific.
- Only for roadside use or exceptionally good terrain.
- Some spray drift problems; a buffer zone is needed around pesticide free areas.
- Wind factor: > 8 km/hr and they can not be used.
- Inexperienced operators can cause crop tree damage from nozzle pressure.
- When extended beyond 100 m, more than one person is required to move hose line.
- Crop trees must be at resistant stage before spraying.

Trailer Mounted

- Needs a lot of room to turn around.
- Expensive.

12. Suitability

- Best suited for brush under 2 m.
- More suitable than backpacks for steep slopes.
- Very effective and productive for roadside work or areas with good road access.

Trailer Mounted

- Suitable for nursery/agricultureal work.

13. Productivity

- Reported 2 ha/day to 20 ha/day depending on conditions, number of hoses and crew size.

VI. CO_2 Sprayer

Figure 5 - CO_2 Sprayer

1. Description

Sprayers that operate on CO_2 have been primarily used for spraying experimental (research) sites. A variety of handheld, backpack or vehicle mounted units are available. The common backpack unit consists of 2 tanks attached to an aluminum back pack frame. One of the tanks is the reservoir for storing the herbicide solution and the second tank contains CO_2, the propellant. A pressure regulator ensures the desired pressure is maintained. A central valve, plumbing and nozzle(s) are located on the spray wand.

2. Physical Specifications

Tank capacity:	10 - 100 L
Tank construction:	Stainless steel
Weight:	< 10 Kg

3. Suppliers

R & D Sprayers
790 Natchez Blvd.
Opelousas, Louisiana
USA, 70570

Other large research/scientific suppliers

4. Availability

Limited in B.C.

5. Additional / Optional Equipment

1. Many types of nozzles/spray guns
2. Various booms and pressure gauges.
3. Quick couplers.

6. Maintenance and Repairs

(a) Daily

1. Clean out tank.
2. Check for leaks on the tank, hose or nozzle.
3. Check delivery rate and recalibrate as necessary.
4. Recharge CO_2 cylinder as required.

7. Method of Operation

Set pressure regulator valve to desired pressure. Open valve on both CO_2 and solution tank. to start spraying open control valve on spray wand.

8. Safety

1. See page C3 for safety requirements while using backpack units.
2. See appendices for safety requirements while mixing.

Personal Protective Equipment

Essential:

1. Water resistant boots.
2. Long pants (preferably water resistant).
3. Jacket (preferably water resistant). Coveralls may substitute for pants and jacket.
4. Unlined plastic (neoprene) gloves

User's Discretion:

1. Water resistant hood or full wide brim hard hat.
2. Face shield or goggles.
3. Respirators to be used when spraying in tall dense vegetation. Respirators may also be required under certain circumstances or as directed by the operator's supervisor.

9. User Assessment

- Need to maintain consistent walking speed, thus require reasonably level terrain with low-to-nil slash/debris.
- Need several CO_2 tanks due to limited capacity.
- Not designed for rough conditions.
- 4 m effective swath width.
- defoaming agent may be required.

10. Advantages

- Extremely accurate delivery.
- Modular assembly allows quick interchange of tank and booms.

11. Limitations and Disadvantages

- Heavy.
- Limited capacity.
- Expensive.
- Tanks require recharging with CO_2.

12. Suitability

- Suitable for experimental (research) applications or small (smaller than 400 m^2) test plots.
- Suitable for treating low vegetation (less than 1 m high).

13. Productivity

- Large research plots - 90 minutes / ha actual spraying time excluding mixing and refilling.

Appendix One
Calibration of Ground Spraying Equipment

A sprayer should be calibrated at the beginning of the spray season, and at times throughout the season. Several factors will affect the calibration:[1]

Vegetation height/density - Low vegetation and/or scattered clumps will require less solution per hectare than taller dense vegetation with greater leaf surface.

Nozzle/pressure - Solution delivery from the sprayer varies with the nozzles used and/or pressure. For most herbicide projects the recommended pressure is 100 to 140 kPa (15 - 20 psi) for backpack sprayers and 175 to 240 kPa (25 - 35 psi) for power operated sprayers.

Ground conditions - for backpack projects the ground conditions (slash, slope, etc.) will affect the workers walking speed, which directly affects the delivery rate per hectare. If conditions vary substantially within the site or from site to site, the equipment should be recalibrated.

The most accurate method of calibration is to actually spray an area of known size and measure the amount of solution used over this known area.

Steps:

1. Partially fill the sprayer with clean water and dye.
2. Ensure there is no leakage from equipment.
3. Test spray sample cards to check spray droplet pattern. If necessary, adjust or change nozzles and pressure to achieve desired spray droplet size.
4. Measure the effective swath width (e.g. 10 m).
5. Fill the spray tank with a known quantity of water.
6. Spray a small homogeneous area (e.g. .25 ha, 10 m x 250 m) at the desired working pressure and speed.
7. Measure the volume of water remaining in the spray tank.
8. Calculate the litres used and determine spray output in litres per hectare (litres used divided by hectares of test).

Generally, the equipment is adjusted to deliver the solution within a certain range (e.g. 75 - 125 L/ha). To achieve the desired rate, the worker can change the nozzles(s) or walking speed. It is not advisable to increase the pressure to increase the delivery rate, as this will result in fine droplets susceptible to drift.

With backpack sprayers, it can be difficult to maintain a consistent pressure and walking speed, which is necessary for uniform application. A pressure regulator valve, which is available as an option if not already built into the sprayer, will ensure uniform delivery of solution. Maintain a constant tally of pesticides used. The amount used should be compared with the area completed in order to check delivery rate.

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[1]Silviculture Manual, Volume 3, Ministry of Forests, 1986 - 1987, Section 12.23

Appendix Two
Productivity Summary

Backpack sprayers had a 50% lower productivity on the coast than in the interior. There is a great variation in productivity due to different delivery rates and site conditions. The interior ranged between 1.6 to 21.6 man hrs/ ha with an average of 6 man hrs/ha.

The motorized backpacks were generally less productive because of increased fill-up time.

The only spot gun report was 8 man hrs/ha in the interior.

Pick-up mounted and trailer mounted units had similar productivities, ranging between 2 to 20 ha/day.

Appendix Three
Safety Considerations: Mixing and Filling

1. Read the product label and check hazard rating.
2. Mix only as much product as needed for one day.
3. Mix in well lit areas with good ventilation.
4. Wear rubber gloves and eye protection.
5. While pouring keep containers below face level.
6. Restrict mixing duties to one or two people depending on crew size.
7. Have emergency wash facilities, first aid equipment and emergency phone numbers close at hand. For more isolated projects (over 20 minutes from a hospital) a radio or radio telephone should be readily accessible.
8. Mix at least 7m from eating areas.

Personal Protective Equipment While Mixing and Filling

Essential:

1. Water resistant boots.
2. Water resistant pants.
3. Water resistant jacket.
4. Water resistant hood or full wide brim hard hat.
5. Unlined plastic (neoprene) gloves
6. Face shield or goggles.

User's Discretion:

1. Respirators may be required in some circumstances.

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APPENDICES

Appendix 1 - Calibration of Stem Injection Tools	D1

Introduction

Most stem injection applications require two tools: one to cut past the bark and cambium layer and another to inject the pesticide in or onto the stem. There are many variations of the basic tools. Many operators have made alterations to the various tools in an attempt to improve safety, productivity and effectiveness.

Many foresters have expressed concern over the success of stem injection operations (mainly hack and squirt). The process relies on the injected pesticide translocating within the plant to kill it.

These points determine the effectiveness of an application:

Timing: Some pesticides must be applied during the plants season of active growth.

Concentration: Due to the cost of pesticides they are commonly diluted for stem injection. This may reduce their effectiveness. Manufacturers recommended concentration must be used.

Weather Conditions: Wet rainy weather at the time of application can dilute the pesticide.

Work Quality: A consistently high standard must be maintained for a successful application.

Most of the stem injection methods are very awkward and unproductive in dense stands of small diameter brush. If stem sizes are less than 5 cm, stump treatments can be used and if the brush is less than 2 m high, ground spraying may be used.

General Safety Considerations

Skin exposure of herbicides is probably the greatest hazard workers face when injecting trees.

Conventional Hack and Squirt poses the greatest threat of chemical exposure. As fill ups are constantly required in the field and minor spills can result, workers should always wear rain pants or disposable clothes and rubber gloves. Proper procedures, eg. removing the axe from the frill prior to the chemical injection, will reduce operator contamination

The newer applicators which have been specifically developed for herbicide use significantly reduce the hazard of operator exposure. The initial expense of these tools is relatively small when spread over the expected life-span of the tool.

Lance Injectors remove the site of treatment away from the worker, greatly reducing the hazard of chemical exposure. In this instance, lance operators need only wear safety gear when refilling.

Chemicals carriers such as the Gel Cap, Ezject and Later's Injector that come filled with premixed herbicide are now available which do away with mixing and filling chemicals in the field.

I. Basic Hack and Squirt

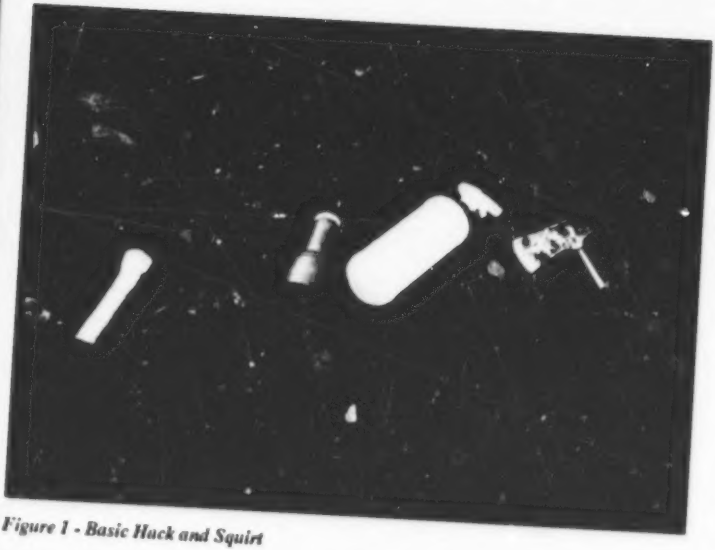

Figure 1 - Basic Hack and Squirt

1. Description

Basic hack and squirt requires a hatchet and a delivery bottle. The blade of the hatchet should be ground to a curve so that it creates a pocket that will better hold the chemical and reduce runoff. Some users ground the head smaller for the same effect. Through practice or modification an ordinary plastic squirt bottle or oil can is adapted to deliver the proper amount of chemical, usually 1ml per squirt.

2. Physical Specifications

Hatchet:	
Weight	ideally 700 g
Handle	metal preferred
Applicator:	
	usually 400 - 1000 mL

3. Suppliers

Hardware or outdoor supply store.

4. Availability

Easily obtainable.

5. Additional / Optional Equipment

1. Large pressurized bottles (2 L) require less fill-ups, but delivery rate varies with pressure.
2. Some nozzles can be calibrated to control flow e.g. Green Cross.

6. Maintenance and Repairs

Daily

1. Check seals on bottle.
2. Keep hatchet sharp to prevent glancing off.

7. Method of Operation

A downward cut is made at a 45^0 angle through the bark and into the cambium layer of the stem. When removing the hatchet, the frill is opened wider to create a good reservoir for the chemical. With the nozzle of the bottle close to the stem the desired amount of chemical (generally 1ml) is applied.

Stem diameter is the major factor in determining the amount of chemical required to achieve control. Dosage is controlled by spacing of the frills around the stem. Directions on the number of notches or amount of chemical required is found on the herbicide label.

8. Safety

1. See Section C appendices for safety requirements while mixing and filling.

Personal Protective Equipment

Essential:

1. Water resistant boots.
2. Coveralls or pants and jacket (preferably water resistant.
3. Unlined plastic (neoprene) gloves.

May be required:

1. Water resistant hood or full wide brim hard hat.
2. Face shield or goggles.
3. Respirator.

9. User Assessment

- This was the most popular method due to its simplicity and inexpensiveness.
- One user recommended a hatchet for stems larger than 15 cm and a Sandvik for smaller.

10. Advantages

- Equipment costs are low.
- Fast and effective method.
- Easy to learn.
- Can be used in conjunction with manual girdling.

11. Limitations and Disadvantages

- Equipment is not designed for herbicide use: potential for leakage from the squirt bottle and operator contamination.
- Difficult to calibrate.
- The hatchet works poorly on large thick barked cottonwoods.
- Not suitable for brush.

12. Suitability

- Best suited for stands with large deciduous trees relative to crop trees.
- Suitable for stems over 4-5 cm.

13. Productivity

- On the coast: from 5.7 to 37.7 man hours/ha, with an average of 14.8.
- In the interior: considerably higher, ranging between .3 to 5.3 man hours/ha, averaging 1.7.

II. Sure Shot Injector®

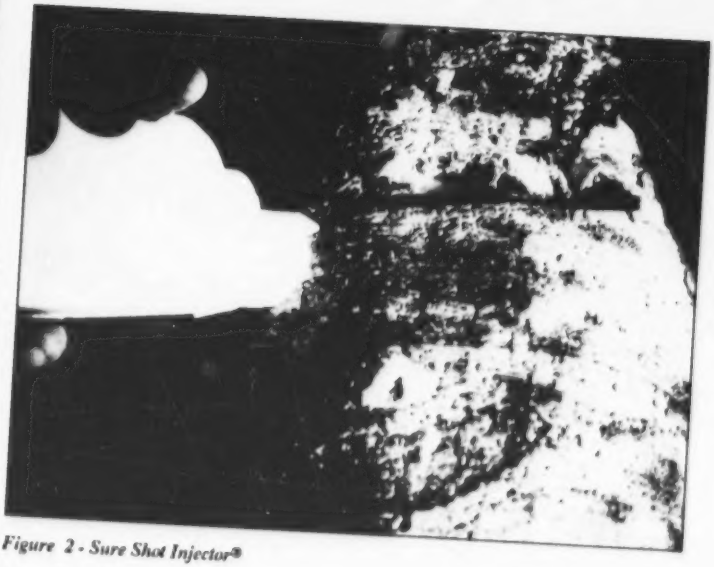

Figure 2 - Sure Shot Injector®

1. Description

The Sure Shot Injector® is an improved squirt applicator to be used in conjunction with a hatchet, punch or other tool. It is designed around a pre-filled disposable container and a reusable applicator head.

2. Physical Specifications

Container 500mL
Comes complete with:
Belt
Holster
Applicator Head

Cost:

Applicator: $62.00
Containers: $3.80 and up depending on chemical and dilution rate. Contact supplier for specifics.

3. Suppliers

United Agri Products
12080 Horseshoe Way
Richmond, B.C.
V7A 4V5
Phone: 271-4224

4. Availability

Readily available from manufacturer.

5. Additional / Optional Equipment

None.

6. Maintenance and Repairs

(a) Daily

1. Flush applicator and holster.
2. Do not burn empty bottles, bury a minimum of 45 cm deep, away from any running water, or return to manufacturer.

7. Method of Operation

To load the premixed bottle onto the applicator head hold the bottle upright in one hand and carefully screw on the applicator head, holding the brass lever against the side of the bottle. A pointed nib inside the head will pierce the sealed cap and the unit is ready.

Create a hack or frill in the stem with the selected tool. When the brass lever is released and the bottle squeezed, the applicator will dispense the chemical into the frill.

8. Safety

Consult section on specific tool used to create frill.

9. User Assessment

- One user recommended using this system with a chainsaw for stump treatments.
- Same user recommended it with a chainsaw for stem injection of large alder > 10 cm where understory was not at risk with the following comments:
- Advantages: Faster than hack and squirt, easy to identify treated areas.
- Disadvantages: Required two workers (sprayer and chainsaw operator).

10. Advantages

- Can be used in conjunction with manual girdling.
- Very little leakage, if any.
- No refilling or mixing chemicals in the field;
- Less chance of spillage.
- Less time spent on refills.

11. Limitations and Disadvantages

- Bottle is small (500ml), necessitates change of cartridge more often.
- Refills are more expensive.

12. Suitability

- Suitable for hack and squirt or stump treatments.

13. Productivity

- A slight increase in productivity because there is no need for mixing and filling bottles.

III. Spot Gun

Figure 3 - Phillips Spot Gun®

1. Description

The Phillips Spot Gun® has a forestry nozzle that can be used for stem injection with either a hatchet or punch. The metal squeeze gun can be set to dispense from 1 to 20 mL per squeeze.

2. Physical Specifications

Tank:	5 L backpack
Cost:	
Basic Unit:	$162
Forestry Nozzle:	$75
Parts Kit:	$20

3. Suppliers

Canadian Forestry Equipment
Forest World

4. Availability

Readily available from supplier.

5. Additional / Optional Equipment

1. Spear for ground injection.
2. Spare parts kit.

6. Maintenance and Repairs

(a) Daily

1. clean nozzle
2. clean tank

(b) As Necessary

1. replace seals

(c) Tools and Spare Parts

1. extra nozzle
2. extra seals

7. Method of Operation

A frill is created in the stem with the selected tool. Press the applicator against the tree and squeeze the trigger to apply the chemical. The quantity of chemical injected is dependent on the trigger setting.

8. Safety

Consult section on specific tool used to create frill.

9. User Assessment

The tool has the potential to be very productive because of the tank size.

10. Advantages

- An improved applicator for hack and squirt.
- Very little leakage, if any
- Can be used in conjunction with manual girdling.
- The 5 L bottle normally lasts the full day reducing mixing and filling times.

11. Limitations and Disadvantages

- Proper calibration may be difficult to achieve due to the broad selection range (1mL to 20 mL).
- The trigger assembly is prone to breakdowns.
- Initial cost is high, however over the life span of the tool the cost would be minimal.
- Hard on the tendons of the hand and arm; poor ergonomics.

12. Suitability

- Suited for hack and squirt and stump treatments.

13. Productivity

- A slight increase in productivity due to less fill-ups required for the 5 L tank.

IV. Hypo-Hatchet®

Figure 4 - Hypo-Hatchet®

1. Description

This tool produces a notch and injects the precise quantity of chemical in one action. A belt holds the chemical container in an inverted position, on the worker's waist. The chemical is delivered from the container to the base of the hatchet by a hose. The chemical is channelled up the inside of the hatchet handle to a loaded piston within the head. Upon impact the piston delivers the chemical, through small holes in the blade, into the notch.

2. Physical Specifications

Weight:	
Hatchet	800 g
Total	3.6 kg
Volume:	900 g
Cost:	Approximately $300

3. Suppliers

Most large forestry equipment can order.

4. Availability

Must be shipped from USA.

5. Additional / Optional Equipment

1. Spare parts kit.

6. Maintenance and Repairs

1. Keep passages clear as required.
2. Keep blade sharp.

7. Method of Operation

Fill the reservoir bottle with chemical and attach to the hose leading to the hatchet. Attach bottle to the belt, wear inverted on your waist, and turn back screw ring from reservoir bottle which allows air to enter as solution is used.

Prime the system by driving the hatchet into a stem until chemical is being injected with each cut. Proceed with treatment of stems by driving the hatchet blade into the stem at a 45^0 angle in a downward motion. It is not necessary to widen the frill as is done with conventional Hack and Squirt. The use of dye in the herbicide will alert the worker to the fact that chemical is no longer being injected (due to lack of chemical or plugged passages in the blade). To a minor extent, the degree of force in which the hatchet is driven into the stem, will allow more or less chemical to be injected to each frill.

8. Safety

1. See Section C appendices for safety requirements while mixing and filling.

Personal Protective Equipment

Essential:

1. Water resistant boots.
2. Long pants (preferably water resistant).
3. Jacket (preferably water resistant). Coveralls may substitute for pants and jacket.
4. Unlined plastic (neoprene) gloves.

May be required:

1. Water resistant hood or full wide brim hard hat.
2. Face shield or goggles.
3. Respirator.

9. User Assessment

Users have experienced numerous problems with this tool. These include:

- Splinters of wood often clog the delivery channels in the hatchet blade.
- In some cases, chemical has remained on the blade from the previous frill and splashed the worker when making a new injection.
- The hatchet is heavy and uncomfortable to use all day.

The only successful reports come from users that have made modifications to the hatchet head. These include removing excess metal from the head to lighten the tool and enlarging the delivery channels to the hatchet blade.

- Removing excess metal from the hatchet head to lighten the tool.
- Enlarging the delivery channels to the hatchet blade. It is not know how this modification will affect the rate of delivery.

10. Advantages

- Cut and inject all in one motion.
- Pre-calibrated delivery.

11. Limitations and Disadvantages

- Hatchet is heavy and expensive.
- Requires considerable daily cleanup and maintenance.
- Holes in the blade can become partially plugged causing variations in the delivery rate.
- Not suitable for brush.

12. Suitability

- Best suited for stands with large deciduous trees relative to crop trees.
- Suited for stems over 5 cm.

13. Productivity

- Lower than conventional hack and squirt due to excessive 'down time'.

V. Punch and Fill

Figure 5 - Punch and Fill

1. Description

This is an improvement (in respect to safety) on the basic hack and squirt process. A sailmakers punch, mounted on the head of a "drywaller's hammer", is used to create a cavity or reservoir in the stem to hold the chemical. The punch is often mounted on a hatchet head to enhance usefulness.

A squirt bottle, such as the Sure Shot® or a spot gun delivers the chemical to the cavity in the stem.

2. Physical Specifications

3. Suppliers

Drywaller's Hammer: Any hardware store
Conversion of head must be done by a machine shop.

4. Availability

No commercial suppliers.

5. Additional / Optional Equipment

6. Maintenance and Repairs

1. Keep punch sharp.

7. Method of Operation

Create a reservoir in the stem by driving the punch into the tree in a slight downward motion. Remove the punch from the stem to extract the core. Place nozzle of the applicator into the hole and apply 1 mL into the reservoir. Space the injections evenly around the stem.

8. Safety

1. See Section C appendices for safety requirements while mixing and filling if required.

Personal Protective Equipment

Essential:

1. Water resistant boots.
2. Long pants (preferably water resistant).
3. Jacket (preferably water resistant). Coveralls may substitute for pants and jacket.
4. Unlined plastic (neoprene) gloves

May be required:

1. Water resistant hood or full wide brim hard hat.
2. Face shield or goggles.
3. Respirator.

9. User Assessment

- One user recommended having the punch mounted on the back of a hack and squirt hatchet with the following comments:
- Use punch and fill on thick bark cottonwood.
- Use the hatchet for alder and thin bark cottonwood or when grooves in the bark are deeper than the punch will reach.
- Some users recommended mounting the punch on a ball pein hammer.

10. Advantages

- Avoids hazard of cuts to workers.
- Faster for thick barked cottonwoods.

11. Limitations and Disadvantages

- Workers preferred hatchet.
- Punches sometimes break.
- Not as versatile as the hatchet.

12. Suitability

- Better suited than a hatchet for thick, grooved bark and rotten wood.

13. Productivity

- Reported to be slightly slower than conventional hack and squirt unless the punch is used with the hatchet. One report was 8 hrs/ha.

VI. Gel Cap®

Figure 6 - Gel Cap®

1. Description

The Gel Cap® system is based on a herbicide filled capsule with a screw housed on the capsule. A special chuck mounted on a commercial battery powered drill screw the capsule into the bark of the target tree. The capsules are as yet unregistered: the manufacturer has applied for forestry registration and expects approval soon.

2. Physical Specifications

Capsule capacity:	1 mL
Capsule cost	$.18 each

3. Supplier

May be leased from:

Pace Chemicals Ltd.
8321 Willard St.
Burnaby, B.C.
V3N 2X3
Phone: 520-6211

4. Availability

Available on a test basis from manufacturer prior to registration. The cost per capsule is expected to drop significantly once they are in full production.

5. Additional / Optional Equipment

1. A battery powered drill is required.
2. A leather carpenter's apron to hold the capsules.
3. Extra battery packs for drill.

6. Maintenance and Repairs

1. Very little maintenance, rinse chuck daily.
2. Recharge batteries as necessary.

7. Method of Operation

The capsule is mounted in the chuck. Screw into the bark of the tree; one capsule for each 6 cm. diameter.

8. Safety

Personal Protective Equipment

Essential:

1. Unlined plastic (neoprene) gloves

May be required:

1. Water resistant boots.
2. Long pants (preferably water resistant).
3. Jacket (preferably water resistant). Coveralls may substitute for pants and jacket.
4. Water resistant hood or full wide brim hard hat.
5. Face shield or goggles.

9. User Assessment

A safe, efficient and effective method for buffer zone and small area treatments.

10. Advantages

- Very little risk of operator exposure.
- No mixing and filling of chemicals in the field and subsequent risk of environmental damage.
- Good for treatments in any season.
- Better than hack and squirt for conifer release as chemical is released slowly and die off takes a number of seasons. Crop trees are subject to gradual sun exposure.

11. Limitations and Disadvantages

- Does not work on birch due to the type of bark.
- Too expensive for use in large scale projects.
- Requires daily access to electricity.

12. Suitability

- Good for small areas such as Pesticide Free Zones and near watercourses.
- Good for thin barked immature trees, thickness of bark - 3mm maximum.
- Use range approximately 2 cm to 15 cm depending on bark thickness.
- Suitable for use at any season except when bark is frozen.

13. Productivity

A productivity study was carried out for Pace Chemicals of Burnaby to compare the Gel Cap® system with conventional hack and squirt methods. The study showed that both systems yield approximately the same man hours per hectare (average 10.8 for Gel Cap® and 12.5 for hack and squirt). Cost per hectare was considerably higher with the Gel Cap® system due to higher product costs.

VII. Lance Type Injectors

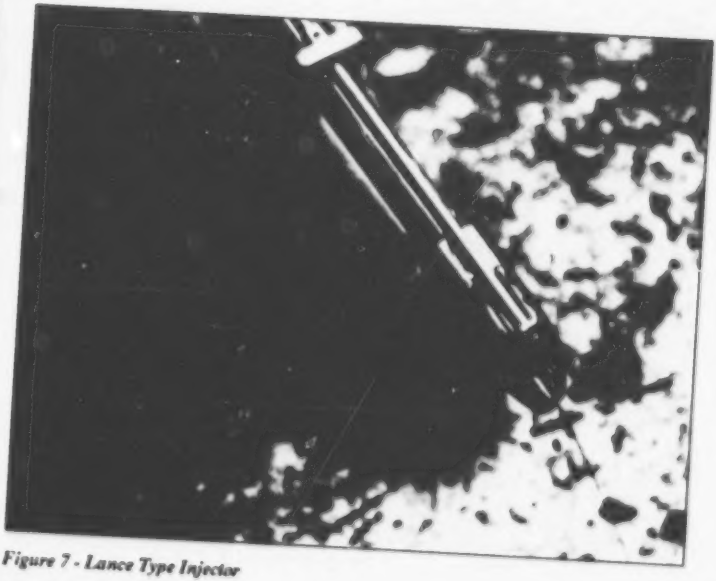

Figure 7 - Lance Type Injector

1. Description

Located on the striking end of the lance is a blade which is used to create a frill in the stem to hold the chemical. Nearby is a nozzle which allows the desired amount of chemical to pass from the storage reservoir into the frill. A check valve located within the system will allow air to enter as the solution is used thus eliminating a vacuum buildup in the storage reservoir. Capacity of the reservoir ranges between .5 to 2.25 L.

2. Physical Specifications

Jim Gem®:

Length:	142 cm
Capacity:	2.25 L
Cost:	approx. $250

3. Suppliers

4. Availability

5. Additional / Optional Equipment

1. Replaceable strainer
2. Sharpening stone and file

6. Maintenance and Repairs

1. Flush daily.
2. Sharpen blade.

7. Method of Operation

Most lance injectors are filled with a liquid product by removing a cap at one end of the lance tube or barrel. The lance is driven into the stem near the ground. The nozzle is activated by a lever, plunger, or the mechanical force created when the lance is driven into the stem.

8. Safety

1. See Section C appendices for safety requirements if mixing and filling is required.

Personal Protective Equipment

Essential:

1. Unlined plastic (neoprene) gloves
2. Water resistant boots.
3. Long pants (preferably water resistant).

May be required:

1. Jacket (preferably water resistant). Coveralls may substitute for pants and jacket.
2. Full wide brim hard hat.
3. Face shield or goggles.

9. User Assessment

Most users preferred conventional hack and squirt to this tool because of its limitations.

10. Advantages

- Chemical sealed in barrel.
- Injection occurs away from the worker.
- Treatment can be a one step procedure.
- Ease of treating clumps or coppices.

11. Limitations and Disadvantages

- Heavy to use and often expensive.
- Difficult to manoeuvre in dense stands.
- Restricted by thick bark e.g. cottonwoods and thick alder.

12. Suitability

- Ideal for clumps of stems.
- Better suited for stems over 5 cm.
- Limited by bark thickness.

13. Productivity

- 11 man hrs/ha reported.

VIII. Eject® (Dillistone We-Do)

Figure 8 - Eject®

1. Description

The Eject® system consists of a hollow 1.5 m long steel lance in which fits a tube of 22 cal. shell casings containing the herbicide. The system comes complete with field boxes, belt and tubes of cartridges. Registration as an approved forestry pesticide applicator has been applied for and the supplier expects approval soon.

2. Physical Specifications

System Cost:	$20 per day
Cartridge Cost:	$.03 per cartridge

3. Supplier

Monsanto Canada
Attn. Larry Taylor

4. Availability

This system has recently been acquired by Monsanto. Contact Mr. Taylor for availability.

5. Additional / Optional Equipment

None; comes as a complete unit.

6. Maintenance and Repairs

(a) Weekly

1. Clean tip.

(b) Monthly

1. Clean magazine.

7. Method of Operation

When pressed firmly against the bole of the tree the shell casing containing the herbicide is injected into the stem. The injected capsule seals the wound preventing chemical leakage. The lance magazine holds up to 450 cartridges which are automatically fed, one at a time, to the tip of the lance.

8. Safety

Personal Protective Equipment

Essential:

1. Unlined plastic (neoprene) gloves

May be required:

1. Water resistant boots.
2. Long pants (preferably water resistant).
3. Jacket (preferably water resistant). Coveralls may substitute for pants and jacket.
4. Water resistant hood or full wide brim hard hat.
5. Face shield or goggles.

9. User Assessment

None available.

10. Advantages

- Not necessary for the field operator to handle chemical directly, thus minimizing exposure and spillage hazards.
- As the chemical is slowly released from the capsule, the die off takes 2-3 years, minimizing stress to crop trees.
- Not restricted by weather or season.

11. Limitations and Disadvantages

- Maple stems greater than 15 cm are best treated in late fall to December.
- Not easy to identify previously treated stems.

12. Suitability

- Best for juvenile spacing with stems 6 cm to 10 cm.
- Suitable for conifer release except on large maples with stems greater than 30 cm.

13. Productivity

- Depending on terrain and density of stand: average 11 to 16 man hrs/ha.
- Reported 2 - 4 times faster than conventional hack and squirt.

IX. Stump Treatments

Stump treatments are carried out in conjunction with clearing applications. The herbicide is applied to increase the effectiveness of the treatment. It is only necessary to treat the vascular layer (ie. the thin layer inside the bark) for the desired effect. It must be applied within 5 minutes of the stem being cut.

Clearing Saw + Stump Treatment Unit

*See Section A, Page A2 for a description of Clearing Saws.

1. Description

The stump treatment unit is designed for installation on a clearing saw. A feed pump, herbicide tank and control handle are fitted to feed chemical to a spray nozzle attached to the back part of the blade. The nozzle feeds herbicide vertically on the lower surface of the blade, close to blade center. A film of herbicide forms on the blade and during sawing the liquid is transferred to the stem surface. The operator can choose which stumps will be treated.

2. Physical Specifications

Stump treatment unit:
Weight 1.3 kg

3. Suppliers

Husqvarna Dealerships, consult yellow pages under "saws".
Enso - Windsor Machine Co.

4. Availability

Usually must be ordered from central supplier in Vancouver for the Husqvarna or Ontario for the Enso.

5. Additional / Optional Equipment

6. Maintenance and Repairs

(a) Daily

1. Rinse device with 10% solution of pine oil soap.

(b) Weekly

1. Lubricate control wire and nozzle arm.

7. Method of Operation

The operator uses the clearing saw in the normal manner and applies herbicide to selected stumps by turning the control handle to activate delivery.

8. Safety

1. See Section A, page A5 for safety requirements for using the clearing saw.
2. See Section C appendices for safety requirements while mixing and filling.

Personal Protective Equipment

Essential:

1. Water resistant boots, pants and jacket.
2. Unlined plastic (neoprene) gloves

3. Full wide brim hard hat or hood.
4. Face shield or goggles.

9. User Assessment

- One user reported no success where terrain was too steep and stem size was greater than 10 cm.

10. Advantages

- Little safety gear required.
- Little operator exposure to herbicide.
- Very productive on good terrain.

11. Limitations and Disadvantages

- Size of trees that may be treated limited due to lack of experienced operators.
- Expensive.

12. Suitability

- Good for trees under 7.5 cm.
- Limited by rough terrain and slash.
- Up to three times production of chain saw treatments ie. .6 ha per day.

Other Types of Stump Treatments

Sandvik® + Spray Bottle

* See Section A13 for a description of the Sandvik for clearing.

10. Advantages

Can be used in conjunction with manual non-chemical treatments.

11. Limitations and Disadvantages

- Slow
- Leaves dangerous spikes.
- Hard on the tendons of the hand and arms.

Chainsaw and Spray Bottle

* See Section A, page A8 for a description of the Chain Saw.

8. Safety

1. Sprayer must always watch the chainsaw operator and should not be near the operator when cutting stems greater than 5 cm..
2. See Section A, page A10 for safety requirements while using chain saw.
3. Consult safety requirements for specific applicator used.

9. User Assessment

- One user recommended the chainsaw/spray bottle combination.

10. Advantages

- Can be used in conjunction with manual non-chemical treatments.
- Easy to get experienced operators.
- Easy to see treated areas.
- The cutter and sprayer can switch to avoid fatigue.

11. Limitations and Disadvantages

- Requires two people - one to cut and one to spray. WCB regulations should be consulted.
- Most dangerous method of stump treatments.
- Crop tree damage will result if the deciduous trees are too big.

12. Suitability

- Good for areas too difficult for ground spraying but too small or dense for hack and squirt.
- Good for site preparation.

13. Productivity

- Productivity reported was approximately 0.2 ha per day depending on terrain and density.

Appendix One
Calibration of Stem Injection Tools

All injection equipment must be calibrated to ensure that accurate delivery and thus correct dosage is achieved. Calibration tests could be carried out using water but due to the increased viscosity of some herbicides, it is advisable to use the actual product. Some variation can occur between identical pieces of equipment and the manner in which it is used by a particular operator. For these reasons, it is advisable for each worker to calibrate their own tools.

Basically, calibration of injection equipment is the process of determining the average quantity of chemical delivered over a series of injections. To determine the average ml per injection, the worker would fill the solution reservoir with a known quantity of chemical. Stems are treated in the normal manner and a count is kept of the number of injections made. After approximately 100 to 200 injections, the quantity of solution remaining in the reservoir is measured to determine the quantity used. The amount used, divided by the total number of injections will determine the average quantity delivered per injection.

The greater the number of injections over which a calibration test is performed, the higher the accuracy of the results.

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AIRCRAFT USED FOR AERIAL HERBICIDE SPRAYING

Both fixed wing aircraft and helicopters are used for forest herbicide spraying. Those described here are:

Fixed-Wing Aircraft

Cessna Ag Truck/Ag Wagon
Piper Pawnee
Piper Brave
Grumman Ag Cat
Thrush Commander

Helicopters

Bell 47G3B1
Bell 47 Soloy
Bell 206B
Hughes 300
Hughes 500 C
Hughes 500 D
Hiller 12E
Hiller 12E Soloy

FIXED WING AIRCRAFT

Model[1]	Fuel Cons.[2] (L/hr)	Wing Span (m)	Max. Boom Span[3] (m)	Est. Swath Width (m)	Spraying Speed[4] (km/hr)	Load (L)	Runway Req.[5] (m)
Ag Truck	65	12.8	9.6	18-22	160-175	600-750	2200
Pawnee	45	11.0	8.2	16-20	145-160	450-500	2000
Brave	70	11.9	8.9	17-21	170-200	800-850	2000
Ag Cat	90	12.8	9.6	18-22	145-160	700-900	2000
Thrush	100	13.4	10.0	18-23	175-190	900-999	2000

HELICOPTERS

Model	Eng. Type[6]	Fuel Type	Fuel Cons.[2] (L/hr)	Rotor Dia. (m)	Max. Boom (m)	Est. Swath (m)	Spraying Speed[4] (km/hr)	Load[7] Range (L)
47G3B-1	P	Gas	70	11.3	8.5	17-22	65-88(72)	225-300(250)
47 Soloy	T	Jet	105	11.3	8.5	17-22	65-88(72)	250-350(300)
Bell 206B	T	Jet	105	10.1	7.6	15-20	72-96(80)	250-350(300)
Hughes 300	P	Gas	55	7.7	5.8	12-15	65-88(72)	175-250(200)
Hughes 500C	T	Jet	100	8.0	6.0	12-16	72-96(80)	225-300(250)
Hughes 500D	T	Jet	130	8.0	6.0	12-16	72-96(80)	275-450(375)
Hiller 12E	P	Gas	80	10.8	8.1	16-20	65-88(75)	250-350(280)
Hiller Soloy	T	Jet	105	10.0	8.1	16-20	65-88(75)	300-450(400)

[1]All are piston engines using avgas
[2]Operational fuel consumption
[3]75% of wing span or rotor diameter
[4]Spray speeds; Optimum in brackets
[5]Runway length required at gross weight, sea level and level ground
[6]P - Piston, T - Turbine
[7]Load range; Normal in brackets

Figure 1 - Fixed Wing Aircraft

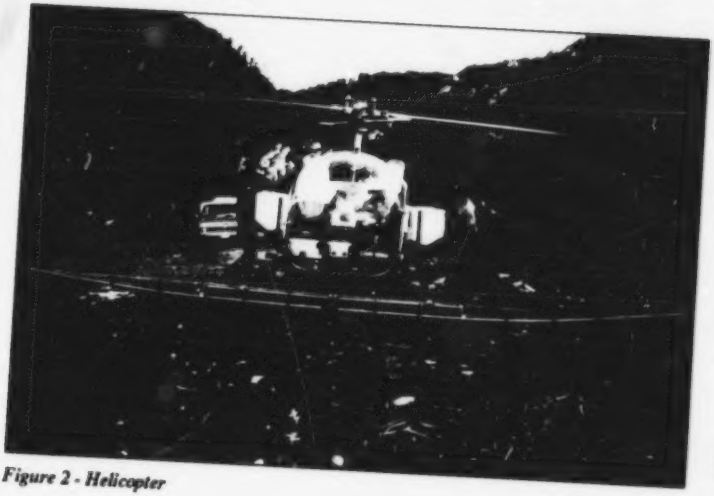


Figure 2 - Helicopter

Additional helicopters that have been used include: Bell 205A-1, Bell 212, Sikorsky S-55, Sikorsky S-58.

These are medium lift helicopters with large capacities. Their use is limited to specific areas due to their size and ground support requirements.

AIRCRAFT SPRAYING SYSTEM COMPONENTS

FIXED WING AIRCRAFT

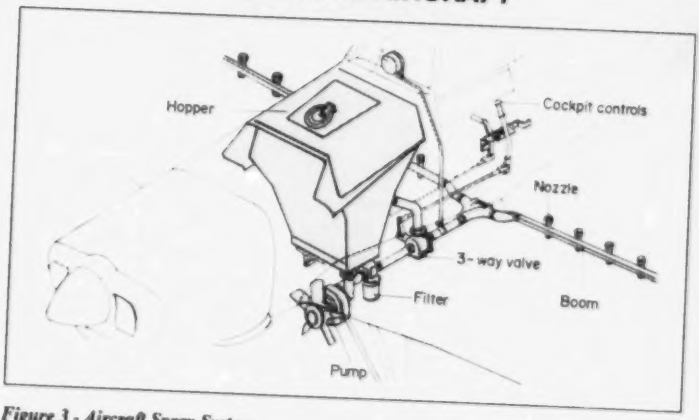


Figure 3 - Aircraft Spray System

All fixed wing aircraft listed here are designed specifically for spraying. The spray systems are an integral part of the aircraft.

Hopper

The tank is mounted in front of the cockpit and as close as possible to the centre of gravity so the aircraft flight characteristics will not be adversely affected as the load decreases. While most tanks are fiberglas, some are stainless steel. They are fitted with baffles to limit the movement of liquid during flight.

Loading

All tanks are capable of being loaded from the top. This operation requires the loader to stand on the wing. The most desirable method of loading is through a quick coupler loading valve mounted on the side of the fuselage immediately rear of the wing.

Capacity Gauges

All tanks have either sight or electrical cockpit gauges which provide a constant check of liquid level.

Pumps

Pumps are usually driven by a fan which is turned by the slipstream of the aircraft. These pumps should have a brake in case of any type of system failure. Some aircraft have been fitted with an electric or hydraulic pump. This allows operation of the system without being airborne.

Filters and Screens

An in-line filter between the tank and the pump will protect the system from contamination and will assist in keeping the nozzles from plugging.

Control Valves

The system is equipped with a 3-way valve operated from the cockpit. In the "spray off" position the liquid is recirculated to the tank. In the "spray-on" position the liquid is directed to the spray booms with a reduced volume returned to the tank. Pressure is controlled by the amount returned to the tank. There is a "booms off" position.

Pressure Gauge

The pressure gauge is mounted in the cockpit and gives the pilot a constant readout of the ooom pressure.

Booms

The boom is usually located behind or below the trailing edge of the wing and is usually 75% of the length of the wing span. It may be round or streamlined hollow pipe with a 1 - 1.5 inch inside diameter.

Special Features

All systems are equipped with emergency dump doors capable of jettisoning the load within 5 seconds.

HELICOPTERS

Figure 4 - Helicopter with Saddle Tank

All helicopters used for herbicide spraying in Canada have an add-on spray system. These systems are available in 3 basic configurations, the belly tank, the internal tank and saddle tanks.

Tanks

Tanks are fiberglas or plastic and include internal baffles to limit the movement of liquids during flight. Tanks are located as near as possible to the helicopter's centre of gravity to reduce changes in flight characteristics during spray operations. The tanks are fitted to special attach points and are normally easily installed and removed.

Loading

All tanks have top loading ports that can be reached while standing on the ground. The most desirable method is through a quick release loading valve on the side of the tank.

Capacity Gauges

Tanks have a sight gauge on the outside of the tank readable while the helicopter is parked on the ground.

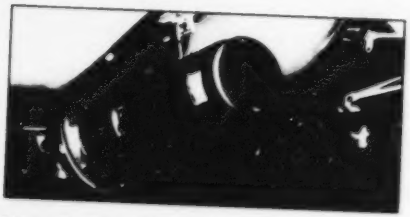


Figure 6 - Electric Motor Pump

Pumps

Pumps are electric or hydraulic driven. They can be operated with the helicopter on the ground and can be shut off in case of a system failure.

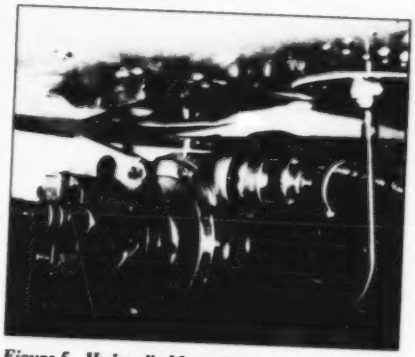


Figure 5 - Hydraulic Motor Pump

Filters and Screens

An in-line filter is normally placed between the pump and the boom. Some systems have a filter incorporated in the fill system as an additional filter or the only filter.

Control Valves

The system is equipped with a 3-way valve operated from the cockpit. In the "spray off" position the liquid is recirculated to the tank. In the "spray-on" position the liquid is directed to the spray booms with a reduced volume returned to the tank. Pressure is controlled by the amount returned to the tank. There

is a "booms off" position. Some older systems do not have the recirculating feature. They have only the "on/off" modes. The pressure is regulated by increasing or decreasing the volume of flow to the booms.

Pressure Gauge

A boom pressure gauge is either mounted on the boom clearly visible to the pilot or mounted in the cockpit. Gauges normally have a dial capacity double the maximum pressure used.

Booms

Booms are hollow tubing of aluminium 1 - 1.5 inches diameter, normally built with bridging to form a truss-like structure. Booms are mounted either on tank hard points or on the helicopter skids near the toe. They are usually connected to the spray tank with quick couplings.

Since most booms extend beyond the rotor diameter care must be taken to ensure nozzles are placed over 75% of the rotor diameter (measuring out each side from the centre) to reduce the amount of spray displaced upwards by the wing tip or rotor vortices.

Special Features

All systems should be equipped with emergency dump doors capable of jettisoning the load within 5 seconds.

Figure 7 - Helicopter with Boom

SOME SUGGESTED SPRAY SYSTEMS

Bell 47 Piston series
- Simplex model 570
- saddle tanks
- electric or hydraulic pump
- boom length - 10 metres
- maximum capacity - 416 litres

Bell 47 Soloy
- Simplex model 4800
- belly tank
- hydraulic pump
- boom length - 10 metres
- maximum capacity - 540 litres

Bell 206B
- Simplex model 4900
- belly tank
- electric or hydraulic pump
- boom length - 11 metres
- maximum capacity - 600 litres

Bell 206B
- Isolair model 3900
- saddle tanks
- electric pump
- boom length - 10 metres
- maximum capacity - 500 litres

Hughes 300
- Simplex model 5200
- saddle tanks
- electric pump
- boom length - 8.5 metres
- maximum capacity - 340 litres

Hughes 500 C/D
- Simplex model 5500
- belly tank
- electric or hydraulic pump
- boom length - 8.8 metres
- maximum capacity - 680 litres

Hughes 500 C/D
- Isolair model 3700
- saddle tanks
- electric or hydraulic pump
- boom length - 8.8 metres
- maximum capacity - 550 litres

Hiller 12E
- Simplex model 3300
- saddle tanks
- hydraulic pumps
- boom length - 10 metres
- maximum capacity - 400 litres

Hiller Soloy
- Simplex model 4500/3200
- saddle tanks
- hydraulic pump
- boom length - 10 metres
- maximum capacity - 530 litres

Hiller 12E or Soloy
- Isolair model 3600 H
- saddle tanks
- hydraulic pump
- boom length - 9.7 metres
- maximum capacity - 548 litres

Other systems are available including internal tank systems for the Hughes 500 and belly tank systems for the Hiller 12E/ Soloy. Most systems use Simplex or Isolair electric or hydraulic driven pumps and simplex booms.

While the above systems listed do not cover all those available these are the most common and cover a good cross section of those in use. Spray systems are also available for the Bell 206 L-1, Bell 204, Aerospatiale A-Star and Llama, and the Hiller FH 1100.

CONVENTIONAL NOZZLES

The most commonly used spray system for conventional herbicide applications is a boom with hydraulic cone nozzles. The nozzle fits into the nozzle body which contains a pressure operated check valve. The valve closes when the spray is turned off and prevents nozzle leakage or dribbling and keeps the booms full so that the system operates quickly when the spray is turned back on.

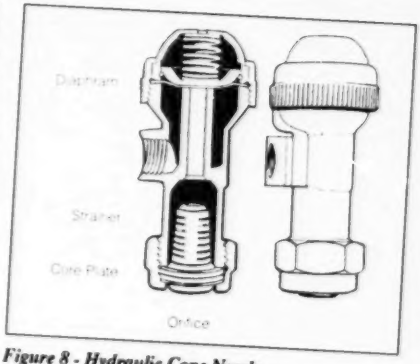


Figure 8 - Hydraulic Cone Nozzle

Nozzles and nozzle parts are available in plastic, brass, stainless steel and hardened stainless steel. Nozzle bodies and caps made of plastic with discs of hardened stainless steel are the suggested nozzle combination for aerial spraying. This minimizes weight while providing critical parts with the most durability. Nozzles should produce droplets as close as possible to the desired size with few droplets of the small drift-prone size or the large oversize.

NOZZLE TYPES

Disc Core

The disc core is a hollow cone nozzle and is designated by the orifice size and the size of the (whirl plate) core used. It produces a hollow circular shaped spray. The orifice is measured in 1\64ths of an inch; i.e. a D-8 orifice has a hole size of 8\64ths (1\8th) of an inch. The larger the core size the larger the droplet size produced and the greater the flow rate. A combination of the disc and the core produces the appropriate droplet and cone size.

Flat Fan Nozzles

The flat fan nozzle produces a flat fan shaped flow from the nozzle. The first two

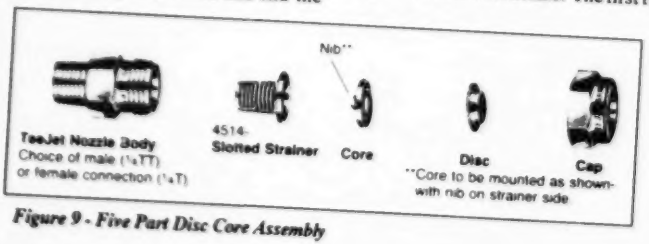


Figure 9 - Five Part Disc Core Assembly

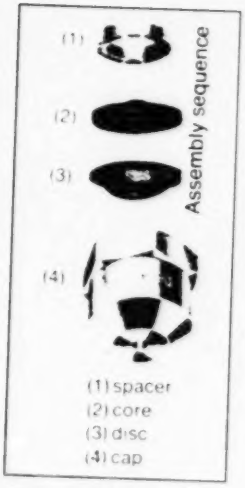


Figure 10 - Raindrop Nozzle Tip Assembly

digits of the code denotes the fan angle unless the first digit is a "1" in which case the first three digits denote to fan angle. The remaining numbers denote the flow rate in U. S. gallons per minute at 276 kPa (40 P.S.I.) pressure.

The amount is determined by placing a decimal point between the first two digits of the flow rate portion. That is an 8002 nozzle has an 80 degree fan with a flow rate of 0.2 U.S. gallons per minute at 40 P.S.I.

Raindrop Nozzles

The Raindrop nozzle is a disc core nozzle with an added chamber which reduces the number of small driftable droplets produced by altering the swirling action of the liquid. It also produces more large oversize drops. An increase in pressure has less effect on the production of small droplets with this nozzle.

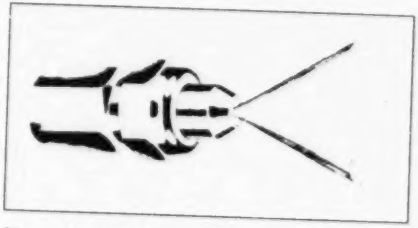


Figure 11 - Solid Cone Nozzle

Figure 12 - Hollow Cone - 'Cone Jet'

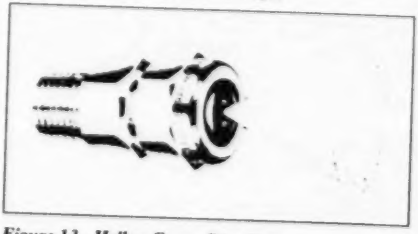


Figure 13 - Hollow Cone - Disc Type

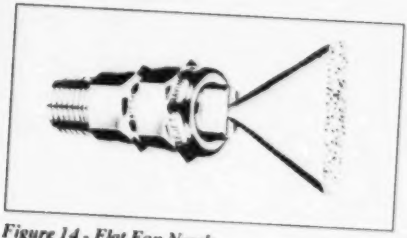


Figure 14 - Flat Fan Nozzle

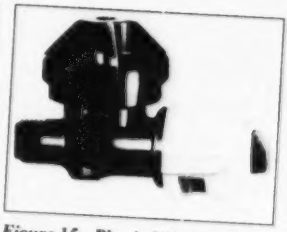


Figure 15 - Plastic Diaphragm for Disc Core or Tee Jet

Disc Nozzle

The disc nozzle utilizes only the orifice in the nozzle body producing a solid stream of liquid. It uses the wind shear created by forward speed or rotor downwash to produce the desired droplet sizes.

OTHER NOZZLES AND BOOMS

Rotary Atomizers

There are two types of rotary atomizers - wind/propeller driven or motor (electric or hydraulic) driven. Micronair produces several wind/propeller driven models. Beecomist produces electric and hydraulic motor driven models. Other companies are entering the field with atomizers with similar modes of operation.

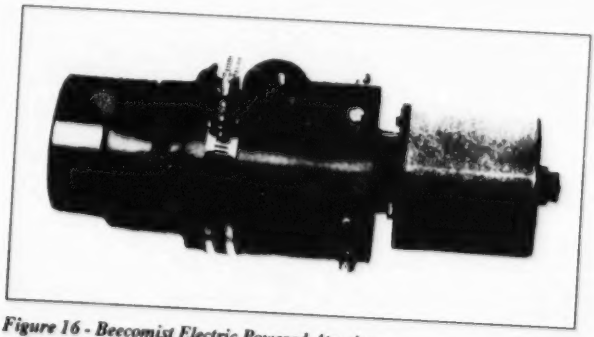


Figure 16 - Beecomist Electric Powered Atomizer

Rotary atomizers are comprised of three major components:

1. a means of delivering the liquid to the inside of a rotating sleeve,
2. the power source, and
3. a porous or perforated sleeve.

The nozzles are attached to conventional booms and have adapters for the liquid flow. The liquid is delivered into the inside of the rotating sleeve at the desired flow rates by installing a disc with the desired size orifice. It is then expelled into the airstream by centrifugal force through the tiny perforations in the sleeve. The speed the sleeve is spinning and the size of the pores or perforations determine the droplet size.

These system normally produce very uniform droplet sizes. They are used extensively for Ultra Low Volume (ULV) insecticides where droplets of 25-125 microns are desirable. Experiments and tests on their use to produce droplets of 250 - 400 microns are being carried out by various agencies.

Microfoil Boom

The microfoil boom was developed as a means of controlling drift when applying herbicides by helicopter. It consists of a series of hollow needles projecting from the trailing edge of a short airfoil boom attached to the systems boom. These hollow needles emit a stream of liquid under very low pressure. A low flight speed minimizes wind shear action.

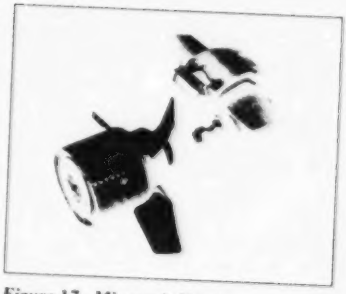


Figure 17 - Micronair Wind Powered Atomizer

This system produces large droplets with very few small driftable dropslets. The swath is very defined and stripping is prevalent. Operational use is limited in broadcast spraying but the increased control makes it suitable for situations such as right-of-ways and roadsides.

Thru Valve Boom

This system was developed by the same source as the Microfoil boom for use at faster speeds and for fixed wing aircraft. Its characteristics and results are similar to the Microfoil boom.

Figure 18 - Helicopter With Microfoil Boom

SPECIAL SPRAY SYSTEM DEVICES

Loading Ports

All spray systems allow for loading through the top of the tank. This can be the cause of problems such as splashing back on the loader, loader being required to climb onto the aircraft, pesticide liquids over the loaders head and system contamination causing plugged filters and leaking nozzles.

Quick connect dry/break load couplers give positive, seal-safe connections. They can be located in an easily accessible location. A closed system is possible whereby the liquid cannot flow without the nozzle being connected to the loading port and turned to lock. To disconnect the coupler is turned to unlock and disconnected. No leakage is possible.

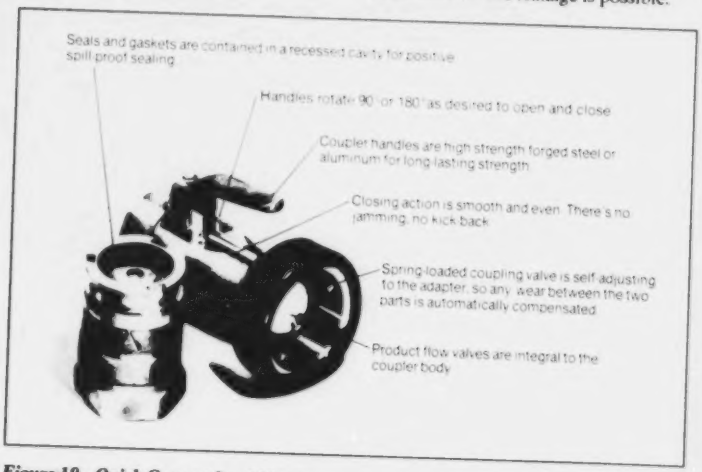
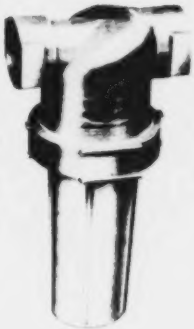

Seals and gaskets are contained in a recessed cavity for positive spill proof sealing
Handles rotate 90° or 180° as desired to open and close
Coupler handles are high strength forged steel or aluminum for long lasting strength
Closing action is smooth and even. There's no jamming, no kick back
Spring loaded coupling valve is self adjusting to the adapter, so any wear between the two parts is automatically compensated
Product flow valves are integral to the coupler body

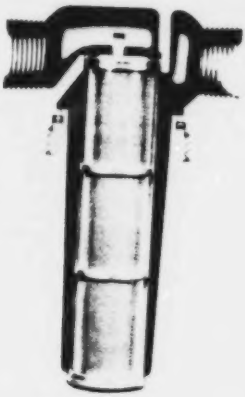
Figure 19 - Quick Connect Load Nozzle

Filters and Strainers

Filters or in-line strainers can be located in two separate areas of the system, sometimes in both. A filter mounted immediately after the dry/break loading port will minimize the loading of contaminants. An advantage of this placement is that it removes the contaminant prior to its introduction into the spray system and as the filter becomes clogged there is no effect on the spray pressure or flow. An in-line filter mounted in the spray system will remove contaminants prior to the spray nozzles. When top loading is used the in-line filter is an absolute necessity. A careful watch for flow and pressure reduction is required as these will occur as a direct result of filter clogging.



124-NY
(Nylon)



Cut-Away View
¾" to 1½" Sizes
(Typical)

Figure 20 - Strainer

Electronic Flow Monitoring System

Electronic flow monitoring systems are metering devices which provide an accurate flow measurement. A constant readout is available to the pilot in litres per minute or litres per hectare plus the volume remaining in the tank. Other optional functions include, among others, total litres sprayed, litres per pass, number of passes, time per pass and hectares per hour sprayed.

Several systems are available including Crophawk and Micronair. They can be adapted to any spray system.

Booms-On Timer

The electronic flow meters provide for a "Booms-On Timer" readout. A directional flow switch is installed in the boom and is activated when out flow past the switch occurs. Comparing this figure with the volume of product used provides the best and most accurate method of checking calibration.

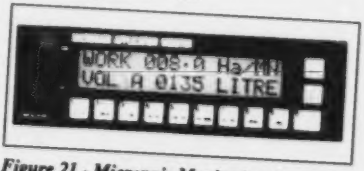


Figure 21 - Micronair Monitoring System

Figure 22 - Crophawk Monitoring System

On/Off Nozzle Valves

On/off valves for conventional nozzles allow for:

a) shutting off residual flow while cleaning the nozzle and
b) extra unused nozzles placed on the boom giving the ability to change flow rates without physically changing nozzles.

Nozzle Extensions

The use of nozzle extensions allows for placing the nozzle tip a minimum of three inches from the boom. This can be accomplished by the use of short pipes or an on/off valve.

This distance places the nozzle tip, and consequently the spray, out of the airflow turbulence created by the boom which can adversely affect the spray droplet size.

Smoke Generators

Smoke generators can be mounted on the aircraft or used on the ground to give a good indication of the air movement at spray height. They can also be used as an aid to navigation.

MIX/LOAD SYSTEMS

Adequate mixing of the herbicide and water is provided by injecting the herbicide into the water stream during loading operations. A minimum of two back flow valves located upstream from the injection are required to prevent any chemical from traveling back to the water source. This system provides for clean water at the loading nozzles at the beginning and end of each load operation.

All product loaded into the aircraft should:

a) be metered through a meter calibrated to the product, and
b) flow through a filter or strainer.

Meters must be calibrated to the product that is being pumped, i.e. water to water flow, product to product flow or mixture to mixture flow. It is not possible to switch from one to another and maintain an accurate flow without re-calibrating the meter.

The closed system mix/load unit is a system whereby the chemical is not exposed to the atmosphere at any point during the operation. Requirements for this system are:

a) 115 litres or larger chemical containers,
b) a pump that does not create foam, and
c) a meter of sufficient accuracy.

This system can be used with either the mix tank unit or the injection system.

MIX TANK SYSTEM

All liquid is metered when it is transferred from one location to another. This is necessary to provide accurate mixtures and applications. Metering or measuring is necessary when water is loaded into the mix tank, chemical is loaded into the mix tank or mixture is loaded into the aircraft.

Closed Mix Tank System

In this system the water is pumped through a meter into the mix tank. The chemical is pumped through a meter directly into the mix tank through a hose coupled to the tank. The chemical pump is mounted on a stand pipe which is pre-installed in the chemical container. The stand pipe is capped until the pump is attached. The correct amount of chemical is loaded into the mix tank and the mix tank inlet valve is closed. There is a dry/break coupler valve located at the chemical meter end of the transfer hose to ensure no leaks on disconnect.

INJECTION SYSTEM

All liquid is measured or metered when chemical is loaded into tank for injection or injected water is loaded into the aircraft. Note: With this system it is desirable to have the meter located after the injection to provide measurement of the full product loaded.

Closed Injection System

In this system the chemical is metered directly into a chemical holding tank with a closed pumping unit identical to the mix tank closed system.

GROUND SUPPORT EQUIPMENT

WATER LOADING

Water loading equipment required consists of a volume suction pump capable of producing 400 litres per minute over a lift of 10 metres. The suction hose requires an inlet screen. A plastic bucket with a flotation ring is desirable to keep the suction screen off the bottom of the water source. A filter located between the pump and the water holding tank is necessary. The filter must be capable of removing all debris that can clog the aircraft's nozzles and all soil particles that can neutralize chemicals. A "Laakos Separator" will fulfill both these requirements.

A water testing kit comprising of two clear plastic jars is necessary to test water for cleanliness. To use the kit fill both jars from the proposed water source, let sit for two hours, shake one jar and compare the liquid's clearness with second jar. If it is less clear, the water may be too dirty.

TANKS

Water Tank

The water tank must have sufficient capacity to provide water for the whole session. The tank is of a non-rust construction, fiberglas, plastic, aluminium, stainless steel or rubber bladder. Internal baffles are required when transporting the water for any distance. The tank must be closed.

Mix tank

The mix tank must be large enough to prepare more than a full mix load for the aircraft being serviced. It should never be filled to more than 75% of capacity allowing for an air separation between the chemical and the water source outlet. The tank must be constructed of chemical resistant material such as plastic, fiberglas, stainless steel or aluminum. A steel tank should never be used as not only can it rust but a chemical reaction with some pesticides (e.g. Vision) can create dangerous gasses.

Chemical Tank

Chemical is stored and transported in the containers supplied by the manufacturer. Immediately prior to use the chemical can be transferred into chemical resistant holding tanks if required for the operation. All tanks must be enclosed with air vents.

AIDS TO NAVIGATION

Several aids are available to assist in determining the previous or future flight paths. This section will cover methods presently being used in B. C. and will list those used elsewhere or that are in the planning stage.

Current Methods

1. Automatic Flagman
2. Del Norte Electronic Flying Flagman
3. Smoke generators
4. Balloon marking
5. Map marking

Other Methods

1. Navigation pointer aircraft
2. Satellite triangulation receiver

CURRENT METHODS

Automatic Flagman

The Automatic Flagman consists of a dispenser mounted on the aircraft which ejects weighted paper streamers along the flight path. Double ended 5 metre streamers of white and orange squares have proven the most visible. A problem with this method is that many streamers disappear into the vegetation where they

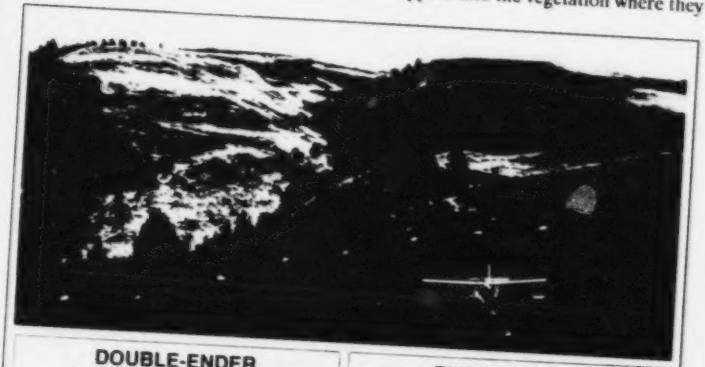

DOUBLE-ENDER
With chipboard weighting at both ends of a 15-ft. white streamer
FLUORESCENT
with chipboard weighting at one end of a 16-foot fluorescent orange streamer

Figure 23 - Automatic Flagman

are not visible. To overcome this a large number of streamers are dispensed each pass, as many as 6 per 400 metres.

Del Norte Electronic Flying Flagman

The Flying Flagman is an electronic triangulation system in which two receiver/transmitter transponders are strategically located on the ground to form a triangulation with a third unit in the aircraft. The resultant information is electronically displayed on a flight instrument providing straight line guidance to the pilot. Accuracy is normally within a metre. Time is required to program the transponders for each block and to set up the transponders in locations where line of sight to the block is available. These time consuming functions make this system unworkable for the majority of spray areas.

Smoke Generators

Smoke generators mounted on the spray aircraft can provide a means of navigation assistance. Smoke is generated during each spray run to mark its location. After the turn at the end of the run the residual smoke is used as a marker. When air movement is present the smoke may drift from location or may break up.

Balloon Marking

With balloon marking, ground personnel with balloons are located at the end of each spray run. As the run is completed they move the measured distance to mark the next run. This system works very well on flat farm fields. It does not work well in the rough, shrub covered terrain normally present when applying herbicides for brush control

Map Marking

Map marking is the most common method of navigations used in forestry herbicide spray operation in North America. The pilot marks his spray runs and loads on a large scale map or aerial photo using terrain and other prominent features as guide points. The pilot then monitors the progression of the application over the block during the operation, comparing it to the projected spray runs and load coverages. Using this system, accompanied by the automatic flagman or the smoke generator, will usually provide good coverage of the area.

OTHER METHODS

Pointer Aircraft

Navigation pointer aircraft are used extensively for insecticide applications in Ontario and New Brunswick. Some pointers are utilized for large block (greater than 400 hectares) herbicide applications in Ontario. Most of these operations use team application aircraft where a wide swath and a long spray run is used.

Satellite Triangulation Receiver

This method of electronic navigation is in use for ships and airborne surveys. A receiver that will provide accurate within one metre is presently being developed and should be available within two years (reference information from Surnav Corporation, November 1988). It will be available for common usage providing all the proposed satellites are launched. Cost for the receiver unit will be in the $20,000.00 range. Accurate block locations in latitude and longitude will be required to program these units.

OTHER EQUIPMENT

CLEAN UP

All systems require that clean water be available throughout the operation. This water source can be a tap on the clean water pump or a "Y" in the water outlet line to provide clean water under pressure for cleaning equipment or personnel or rinsing chemical containers

1. **Spill Clean Up Kit**
   - 10 kgs agricultural white lime
   - 40 kgs
   - Kitty litter or Peat Moss
   - Nutra Sol
   - Plastic garbage bags - large size
   - roll of polyethylene
   - 2 shovels
   - 1 rake
   - Rope and flagging
   - Personnel safety gear
2. **Fire Extinguisher**
3. **First Aid Kit**
   - B. C. #2 first aid kit
   - Syrup of Ipecac or salt
   - Bag of activated charcoal
   - Eye Wash
4. **Nozzle Cleaning Kit**
   - wash basin
   - liquid detergent soap
   - soft bristle brush
   - roll of string
   - spare discs
   - spare cores
5. **Defoamer**
6. **Heliport Wind Marker**

The heliport wind marker is usually a colored ribbon tied to a tree visible from the heliport but not affected by the movement of the rotor blade while reloading.

MANUFACTURERS AND PRODUCTS

Manufacturers	Products
Automatic Flagman Company Route 4, City/County Airport Walla Walla, Washington 99362	Automatic Flagman
Beecomist Systems 31 Meeting House Rd., Telford, Pennsylvania 18969	Rotary Atomizers
Crown Rotational Molded Products Inc. P. O. Box 577 Marked Tree, Arizona 72365	Plastic tanks

Manufacturers	Products
Delavan Agspray Products 20 Delavan Drive Lexington, Tennessee 38351	Nozzles and accessories
Emco Wheaton, Inc Chamberlain Blvd., Conneaut, Ohio 44030	Dry/break couplers and valves
Isolair 204090 E. Aschoff Road Rhododendron, Oregon 97049	Helicopter spray systems Spray system components
Liquid Controls Corporation Wacker Park North Chicago, Illinois 60064-0101	Meters and accessories
Micronair Sales and Service 7792 N.W. 54th St., Miami, Florida 33166	North American rep for Micronair Rotary Atomizer and Electronic flow meter
Norweaco 4365 Steiner St., St. Bonifocius, Missouri 55375	Plastic tanks
Onboard Systems P.O. Box 03413 Portland, Oregon 97203	Crophawk Electronic Flow Meter
Scienco 5558 Federal Ave., Memphis, Tennessee 38118	Fieldflow chemical transfer pumps and meters
Simplex Manufacturing Co. 13340 N. E. Whitaker Road Portland, Oregon 97230	Helicopter spray systems Spray system components
Spraying Systems Co. North Avenue and Schmale Road Wheaton, Illinois 60187	Spray nozzles Nozzle components Nozzle accessories

Manufacturers	Products
Surnav Corporation 1000 - 38 Antares Dr., Nepean, Ontario K2E 7V2	Electronic Navigation Systems
Transland, Inc. 24511 Frampton Ave., Harbor City, California 90710	Aerial application equipment for fixed wing and helicopters
Tuthill Corporation Baer Feild Fort Wayne, Indiana 46809	Meters

LOCAL DISTRIBUTORS AND DEALERS

Arbor Applicating Ltd
P.O. Box 675,
Abbotsford, B. C.
V2S 6R7
Phone: 604 850-0989
Fax 604 859-6830

Distributor for:
Simplex Manufacturing - Helicopter spray system and components
Beecomist - Rotary Atomizers
Spraying Systems - Tee Jet nozzles
Delavan - Raindrop nozzles
Onboard Systems - Crophawk Flow Meter
Automatic Flagman - Flagman and Flags
Crown Rotational - Plastic tanks
Emco Wheaton - Dry/break couplers

H.G. Equipment Inc.,
5 E. 1st
Burnaby, B. C.
V5C 3V6
Phone: 604 291-8427
Fax 604 291-1619

Liquid Controls - Meters and meter accessories
Norwesco - Plastic tanks
Pumps
Valves

John Brooks Canada Ltd.,
2429 Canoe
Coquitlam, B. C.
Phone: 604 942-7622

Spraying Systems - Tee Jet nozzles and nozzle accessories
Pumps Meters
Valves

These lists for Manufacturers and Distributors are not a complete list but give a sample of where spray systems and accessories are available.